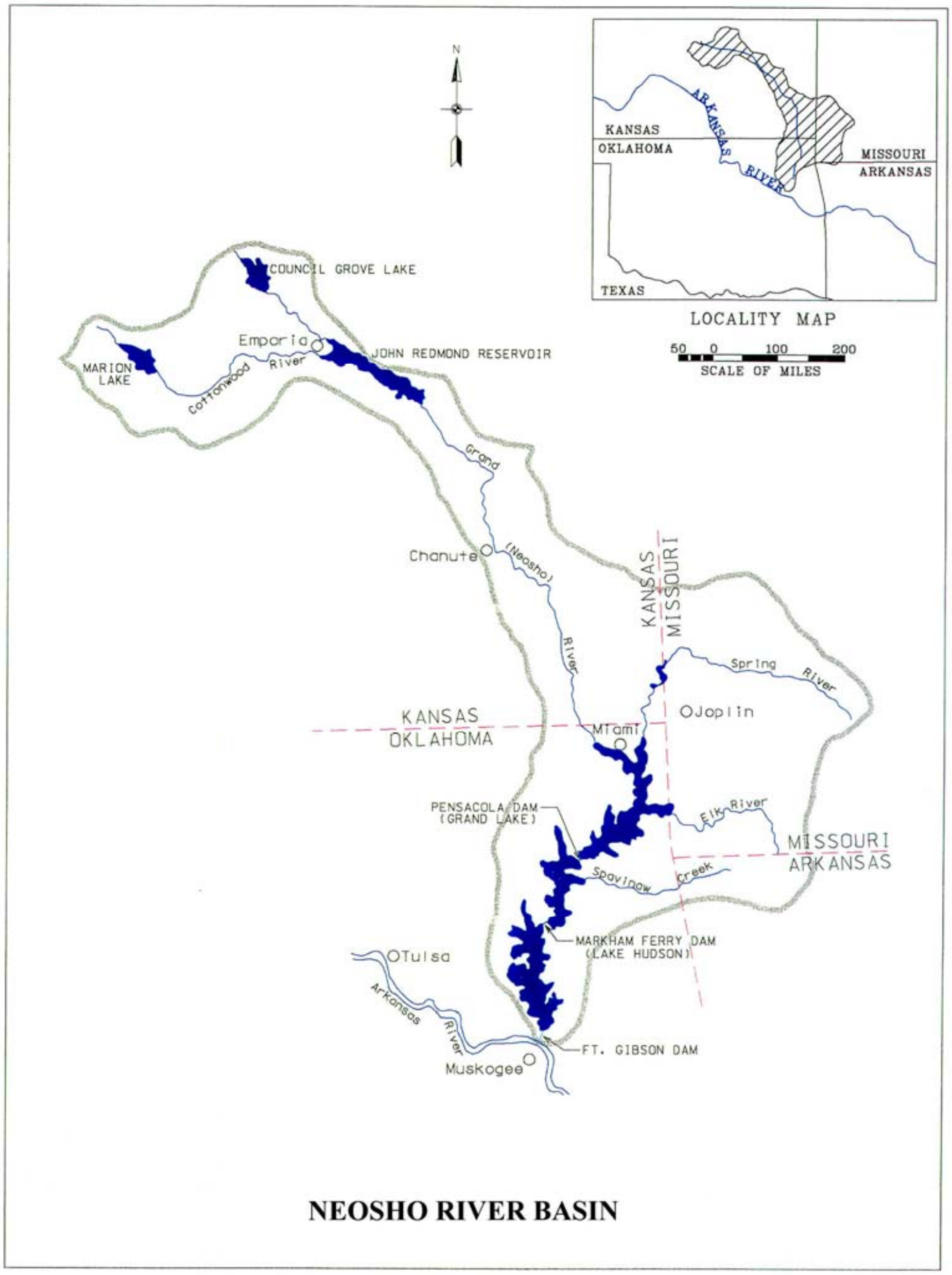
CESWT Draft 9 August 2002

GRAND LAKE, OKLAHOMA
PRELIMINARY ANALYSIS OF FLOOD CONTROL OPERATION



US Army Corps of Engineers®
Tulsa District

August 2002

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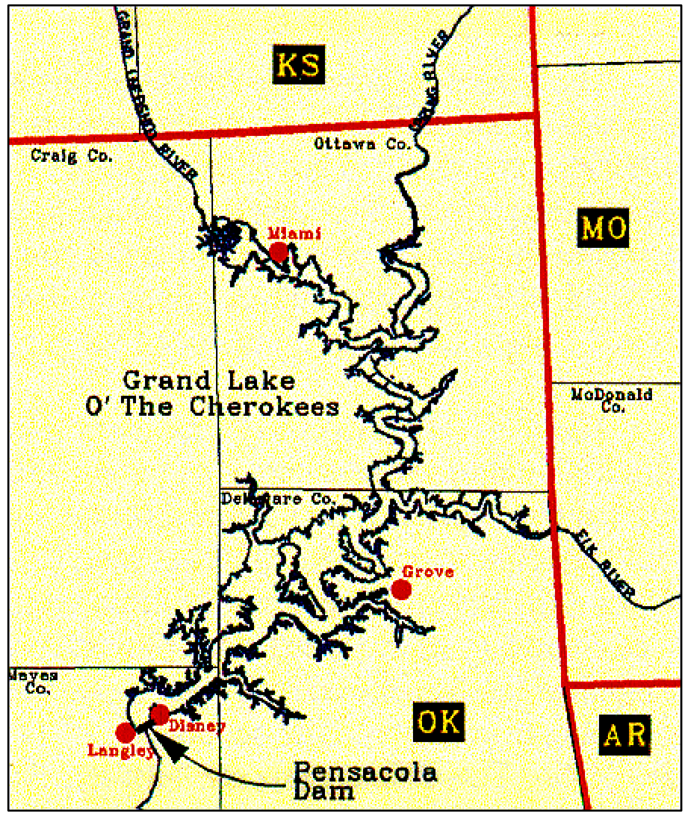


PURPOSE AND SCOPE OF STUDY

This interim study was conducted in partial response to the Water Resource Development Act of 2000, Section 449, Grand Lake, Oklahoma.

The Corps of Engineers September 1998, Grand Lake, Oklahoma, Real Estate Adequacy Study, evaluated the backwater effects of current lake operations for the combined operating purposes of flood control (directed by the Corps) and hydropower (operated by the Grand River Dam Authority (GRDA)). That study was authorized by the Water Resources Development Act of 1996, Section 560. Grand Lake was treated as a "potential project," and current criteria were used to determine the scope of backwater impacts and the limits of flowage easements that would have been recommended for acquisition using the administrative approach to acquisition requirements of a potential reservoir project. Historic flood data were used in hydrologic and hydraulic evaluations (part of the current criteria) to estimate theoretical backwater impacts as if Grand Lake were a potential project. This "potential project" approach provides an estimate of real estate impacts throughout "future" project life. Mapping was developed to show the limits of flowage easements that would have been recommended for acquisition and the limits of existing easements at Grand Lake. Areas were found around the lake where, using current criteria and based on current lake operations, additional flowage easements would be recommended if Grand Lake were a "new" project. Analysis of a selected number of historic floods on the Grand River indicated that backwater impacts due to Pensacola Dam have exceeded existing flowage easements, and these areas would not have flooded during those events without the dam in place. Theoretical backwater effects of Grand Lake were found to exceed the limits of existing flowage easements using the criterion of a 50-year land acquisition flood. If Grand Lake were a new Federal project and real estate were acquired using the guide taking rules of the Southwestern Division, which is a guide for determining flowage easements including freeboard, approximately 3,500 acres of additional easements would be considered for real estate acquisition. It was estimated that about 1,600 residences and businesses were located in the approximately 3,500-acre area. About 200 of the 1,600 structures were located in the vicinity of Miami, Oklahoma. The locations and relative sizes of areas where backwater effects were found to exceed the limits of existing flowage easements ranged from small areas in the vicinity of Pensacola Dam and throughout the lake to larger areas along the upstream reaches of the Grand (Neosho) River. This includes areas in Miami and in the vicinity of Miami. It was also estimated that about 1,600 additional residences or businesses are located within the limits of existing easements that cover an area of about 11,700 acres. A full determination of the exact extent of backwater impacts of Pensacola Dam was beyond the scope of the 1998 study. Moreover, backwater impacts specifically due to flood control operations on lands around the reservoir, for which real estate interests are not held, were not evaluated. That study did not differentiate the relative contributions of flood control or hydropower to backwater impacts.

Section 449 directed the Corps to evaluate backwater effects specifically due to flood control operations on land around Grand Lake, Oklahoma. In partial response to Section 449, and subject to the limitations of available funds, hydraulic studies were conducted to determine the backwater effect of flow along the Grand (Neosho) River reach of the lake and upstream area for with- and without- flood control operating conditions. Current analyses were conducted for the same set of historic storm reproductions evaluated in the 1998 study, as well as the same theoretical (frequency) flood events. Plate 1 shows the Grand (Neosho) River reach included in this study.

STUDY AUTHORITY

Section 449 from the Water Resources Development Act of 2000 follows:

Section 449. GRAND LAKE, OKLAHOMA.

(a) EVALUATION- The Secretary shall--

(1) evaluate the backwater effects specifically due to flood control operations on land around Grand Lake, Oklahoma; and

(2) transmit, not later than 180 days after the date of enactment of this Act, to Congress a report on whether Federal actions have been a significant cause of the backwater effects.

(b) FEASIBILITY STUDY-

(1) IN GENERAL - The Secretary shall conduct a study to determine the feasibility of--

(A) addressing the backwater effects of the operation of the Pensacola Dam, Grand/Neosho River basin, Oklahoma; and

(B) purchasing easements for any land that has been adversely affected by backwater flooding in the Grand/Neosho River basin.

(2) COST SHARING - If the Secretary determines under subsection (a)(2) that Federal actions have been a significant cause of the backwater effects, the Federal share of the costs of the feasibility study under paragraph (1) shall be 100 percent.

GRAND LAKE DESCRIPTION AND LOCATION

Grand Lake O' The Cherokees (also called Grand Lake and Pensacola Dam) is located on the Grand (Neosho) River in northeastern Oklahoma. The Grand River, called the Neosho River in Kansas, is a tributary of the Arkansas River and covers parts of Kansas, Missouri, Arkansas, and Oklahoma. Six multipurpose reservoirs, including Grand Lake, have been constructed in the 12,500-square-mile Grand/Neosho River Basin. The Pensacola Dam for Grand Lake is located at river mile 77.0 of the Grand (Neosho) River in Mayes and Delaware counties near Disney, Oklahoma. The lake is sinuous with a maximum depth of about 140 feet at the dam. The lake has a length of about 65 miles along the Grand (Neosho) River, with widths at normal pool varying regularly from about 600 to 8,000 feet. The average stream invert slope along the river channel is about 1.6 feet per mile. The reservoir covers over 72 square miles and has a shoreline of over 1,340 miles. Grand Lake was designed and constructed by the Grand River Dam Authority (GRDA), an agency for the State of Oklahoma, for flood control and hydropower. Grand Lake is considered a retirement center for the region, and recreation, business, and retirement interest around the lake continues to increase.

GRAND (NEOSHO) RIVER DESCRIPTION

The Grand (Neosho) River is the major contributor to Grand Lake inflow. The river starts in central Kansas, flows south through numerous towns, and combines with Grand Lake in the vicinity of Miami, Oklahoma. The Grand (Neosho) River channel is well defined throughout the study reach. The channel depth at normal bank varies from 18 to 22 feet. The channel width varies from about 250 feet to about 400 feet and has an average invert slope of about 1.4 feet per mile. Overbanks are predominantly flat agricultural lands, with some dense wooded lands adjacent to the channel and along tributary streams. Overbanks vary from 3,000 feet to over 6 miles wide.

HYDRAULIC ANALYSIS

The backwater model developed for the Grand (Neosho) River in the September 1998 Grand Lake Real Estate Adequacy Study was used for this study. Cross section information was developed from 2-foot contour interval aerial topography developed for the September 1998 study. Topography generally covered the entire reservoir pool area plus potential backwater areas along major tributaries, including the Grand (Neosho) River arm. The model was verified using discharge and elevation information obtained from gages and local data collectors along the Grand (Neosho) River for the six historic storms shown in this report. Frequency discharges were developed from detail modeling for each of the major tributaries to Grand Lake. Each basin model incorporates parameters specific to the basin including soil types, infiltration rates, percent impervious, rainfall, and evaporation. Each tributary was verified with gage data for numerous storm events including the six historic storms shown in this report. The backwater elevations and profiles were computed using the U. S. Army Corps of Engineers Computer Program HEC-RAS, "River Analysis System", Version 2.0; April 1997. Pertinent information used to develop the HEC-RAS model is discussed in the referenced document - http://www.swt.usace.army.mil/library/libraryDetail.cfm?ID=78 .

Starting Conditions

For modeling conditions with Pensacola Dam along the Grand (Neosho) River, the pool elevation corresponding to the frequency inflow discharge taken from the pool frequency curve was used. A pool elevation of 746.1 was used for starting conditions for Pensacola Dam without flood control storage. Starting conditions for the frequency flow model are shown in Table 1. Historical storms were reproduced with pool elevations occurring at the time of peak flow along the Grand (Neosho) River. Pertinent data and starting water surface elevations for each historical storm are shown in Table 2. Lake elevations used for backwater computations are in NGVD 1929 datum and not Pensacola Datum (PD). Elevations in PD have been modified by adding 1.1 feet to convert to NGVD.

TABLE 1

GRAND (NEOSHO) RIVER STARTING WATER SURFACE ELEVATIONS

Frequency Return Period	Alternative		
	Pool Frequency	No Flood Control	Maximum Pool
2-Year	749.9	746.1	756.1
5-Year	753.9	746.1	756.1
10-Year	755.2	746.1	756.1
25-Year	755.9	746.1	756.1
50-Year	756.0	746.1	756.1
100-Year	756.1	746.1	756.1
SPF	756.1	746.1	756.1

TABLE 2

GRAND (NEOSHO) RIVER HISTORICAL STORM PERTINENT DATA

Storm	Grand (Neosho) River Peak Discharge (cfs)	Grand Lake Elevation @ Grand (Neosho) River Peak Discharge (NGVD)	Pensacola Dam Peak Pool Elevation (NGVD)
October 1986	122,700 (6 Oct 2100)	756.03 (6 Oct 2100)	756.09 (6 Oct 1800)
December 1992	47,900 (16 Dec 1900)	754.76 (16 Dec 1900)	755.22 (18 Dec 0200)
September 1993	75,800 (27 Sep 2100)	755.20 (27 Sep 2100)	755.61 (28 Sep 1100)
April 1994	93,800 (13 Apr 1500)	752.55 (13 Apr 1500)	755.45 (15 Apr 1100)
June 1995	71,600 (12 Jun 1700)	755.66 (12 Jun 1700)	756.08 (14 Jun 0100)
October 1998	50,000 (07 Oct 1330)	749.45 (07 Oct 1330)	750.70 (08 Oct 2100)

Backwater Runs

Backwater profiles were computed along the Grand (Neosho) River for six historical storms and six frequency events to determine the flooded area limits of the effects of flood control operation. Also modeled was the condition that may have existed if Grand Lake were operated without flood control storage. Each historical storm and frequency event was compared between the with-flood control and the no flood control models. The results of these comparisons are presented in Tables 3 and 4. The extent of the area flooded is shown on Plates 1 through 11. Water surface profiles for each condition are shown on Plates 12 through 18.

SUMMARY

The Grand (Neosho) River has experienced numerous significant storm events in the past 50 years. Significant storms in recent history occurred in July 1951, October 1986, December 1992, September 1993, April 1994, and June 1995. Calculated historical peak flows along the Grand River near Miami ranged from 48,000 cfs to 251,000 cfs for these storms. The backwater effect for each historical event and frequency flow condition presented in this document is shown only as it relates the flood pool elevation of Grand Lake. The effects of operation with and without flood control are dependent on pool elevation, lake inflow, other tributary flows, and location. The flooded areas and profiles shown for no flood control operation are based on maintaining a release schedule such that the maximum pool elevation would be 746.1. This represents an ideal situation that may not be a true representation of the capabilities of the field personnel or the structure to adjust releases, but it is a reasonable and conservative assumption for evaluation purposes.

CONCLUSIONS

From this interim analysis and for selected frequency floods and historic flood events, the backwater effect from Grand Lake on the Grand (Neosho) River:

- Does not extend upstream of the Commerce Gage at station 4045+36 along the Grand (Neosho) River.
- The differences between with and without flood control storage evaluations are most prominent on the Grand (Neosho) River from Twin Bridges State Park upstream to the Tar Creek confluence.
- Flood control operations for selected **historic** events appear to impact lands where no easements are held.
- Flood control operations for selected **frequency** flood events indicate a potential for future flood control operations to impact lands where no easements are held.
- Some of the selected frequency floods and historic flood events would have exceeded the limits of existing flowage easements for the without flood control condition (hydropower only).
- All evaluated flood events would tend to exceed the limits of existing flowage easements to a greater extent for the with flood control operation condition (flood control and hydropower).

RECOMMENDATIONS

Whereas these interim analyses were not intended to and do not represent all potential impacts due to flood control operations, they do indicate a potential for impacts to lands around Grand Lake where flowage easements have not been acquired. This finding appears to meet the criteria established in Section 449 of the Water Resources Development Act of 2000 which directs that the Federal share of a feasibility study be 100% Federally funded. However, a 100% Federally-funded feasibility study is not supported by administration policy.

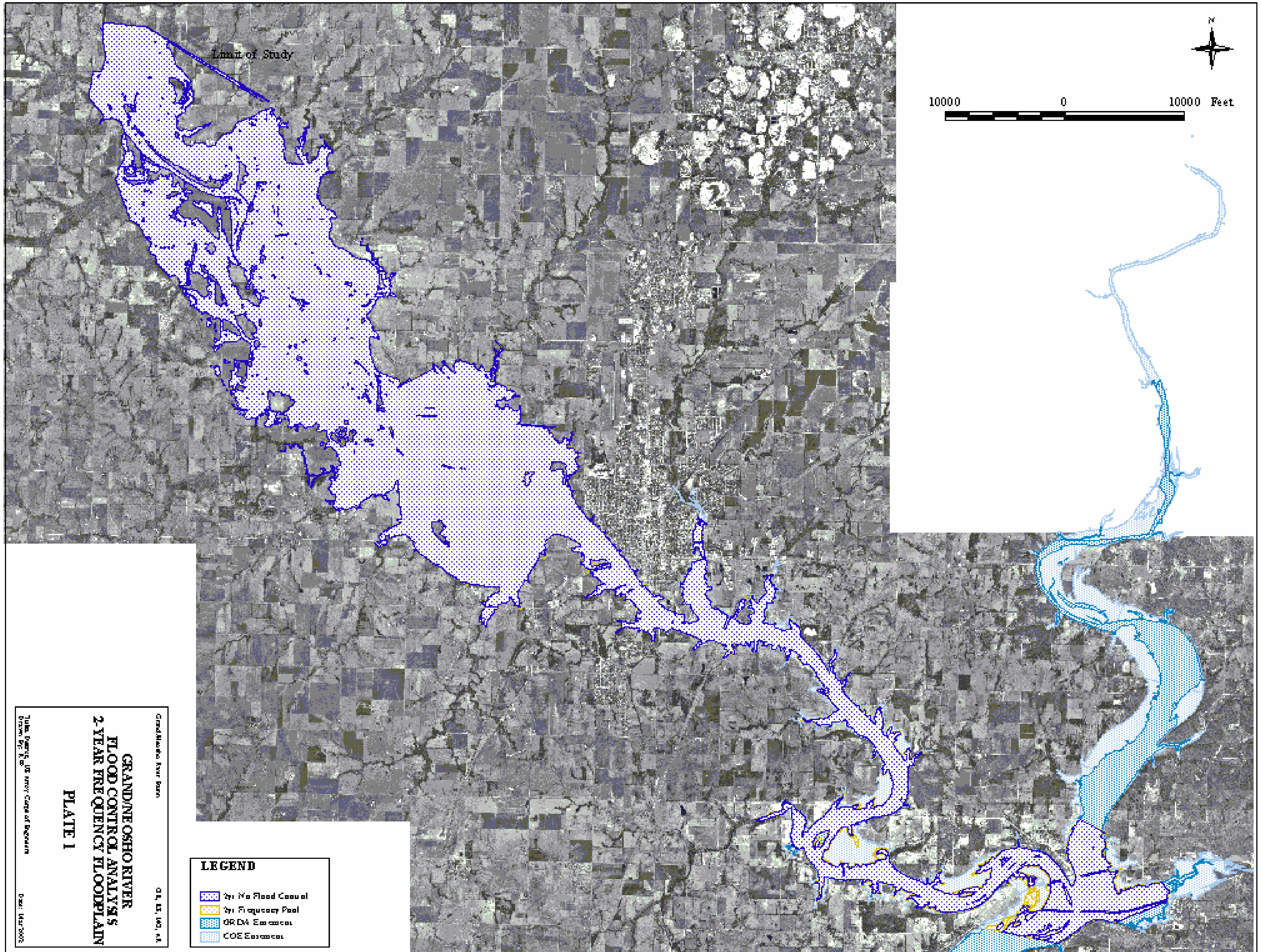
TABLE 3
WATER SURFACE ELEVATIONS FOR FREQUENCY DISCHARGES
WITH AND WITHOUT FLOOD CONTROL STORAGE

Description	Cross Section	2-year		5-year		10-year		25-year		50-year		100-year	
		Freq	No FC	Freq	No FC	Freq	No FC	Freq	No FC	Freq	No FC	Freq	No FC
Twin Bridges State Park	280117	751.4	748.6	755.7	750.1	757.9	752.6	760.5	755.7	762.3	758.6	764.5	762.1
Hwy 60 Bridge	280670	751.4	749.2	755.7	751.1	757.9	752.6	760.5	755.7	762.3	758.6	764.5	762.1
County Road	302612	753.5	752.1	758.1	755.5	760.7	757.9	763.8	761.6	766.8	765.1	770.1	769.1
Will Rogers Turnpike	341616	758.6	758.3	763.2	762.4	766.1	765.2	769.8	769.1	773.4	772.9	776.9	776.6
Tar Creek Confluence	342196	758.8	758.4	763.3	762.6	766.2	765.4	770.1*	769.3	773.7	773.2	777.3	777.0
Abandoned RR Bridge	345889	759.9	759.6	764.3	763.7	767.4	766.6	771.7	771.0	776.1	775.7	778.1	777.9
Hwy 125 Bridge	350312	761.0	760.7	765.5	765.0	768.7	768.1	773.2	772.6	777.0	776.7	779.2	779.0
Hwy 10 Bridge	352887	761.7	761.5	766.2	765.7	769.3	768.8	774.1	773.5	777.6	777.4	779.9	779.7
Commerce Gage	404554	769.2	769.2	770.9	770.9	772.5	772.3	776.1	775.7	779.2	779.1	781.3	781.2

TABLE 4

WATER SURFACE ELEVATIONS FOR HISTORICAL FLOOD EVENTS
WITH AND WITHOUT FLOOD CONTROL STORAGE

Description	Cross Section	October 1986		December 1992		September 1993		April 1994		June 1995		October 1998	
		Actual	No FC	Actual	No FC	Actual	No FC	Actual	No FC	Actual	No FC	Actual	No FC
Twin Bridges State Park	280117	760.1	755.6	757.2	752.1	760.6	756.7	760.3	758.0	757.6	751.7	753.6	752.2
Hwy 60 Bridge	280670	760.1	755.6	757.2	752.1	760.6	756.7	760.3	758.0	757.6	751.7	753.6	752.2
County Road	302612	763.3	761.1	758.4	754.8	762.4	759.7	762.9	761.6	760.0	756.9	756.0	755.0
Will Rogers Turnpike	341616	769.1	768.4	762.0	760.6	766.6	765.5	768.2	767.8	765.2	764.2	761.2	760.9
Tar Creek Confluence	342196	769.3	768.6	762.1	760.7	766.7	765.6	768.4	768.0	765.3	764.4	761.4	761.1
Abandoned RR Bridge	345889	770.8	770.1	762.9	761.8	767.7	766.8	769.7	769.3	766.4	765.6	762.4	762.1
Hwy 125 Bridge	350312	772.2	771.7	763.9	763.0	768.9	768.1	771.1	770.7	767.7	767.0	763.5	763.4
Hwy 10 Bridge	352887	773.1	772.6	764.5	763.7	769.5	768.8	771.8	771.5	768.3	767.7	764.2	764.1
Commerce Gage	404554	775.2	775.0	770.0	770.0	772.5	772.2	774.2	774.1	771.9	771.8	770.2	770.2


Limit of Study
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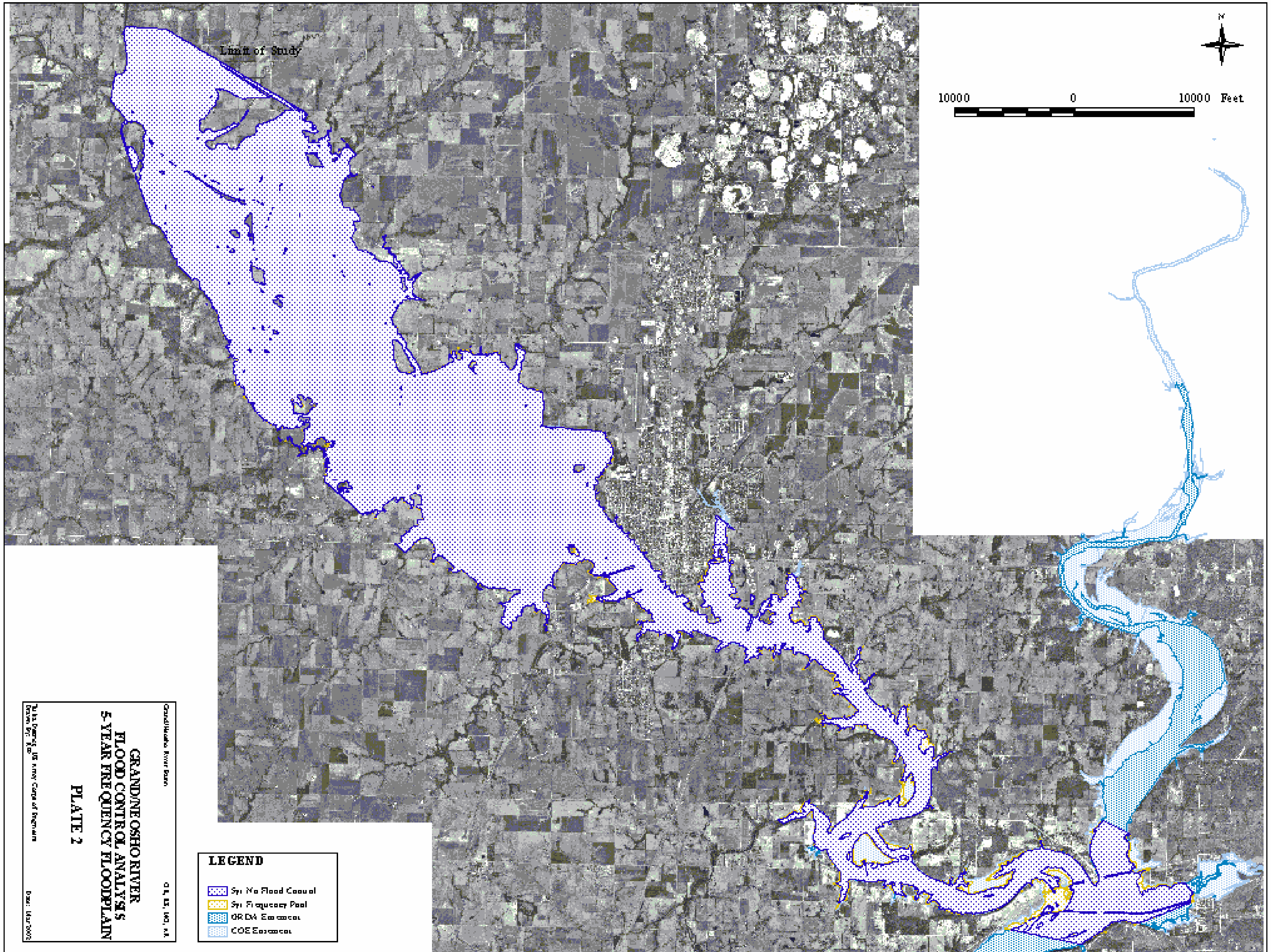
GRAND/NEOSHO RIVER
FLOOD CONTROL ANALYSIS
2-YEAR FREQUENCY FLOODPLAIN
PLATE 1
LEGEND


Limit of Study
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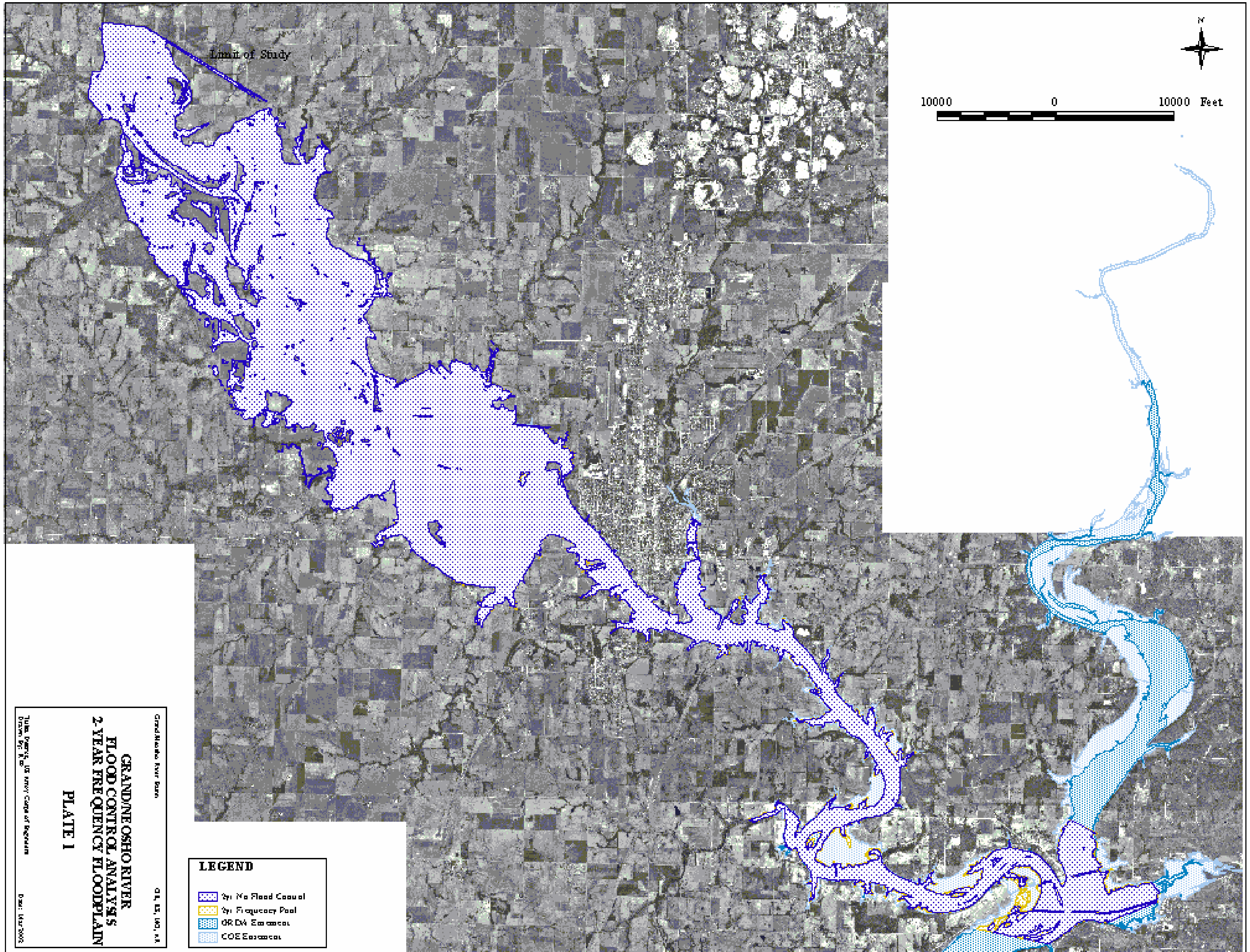
GRAND/NEOSHO RIVER
FLOOD CONTROL ANALYSIS
5-YEAR FREQUENCY FLOODPLAIN
PLATE 2
LEGEND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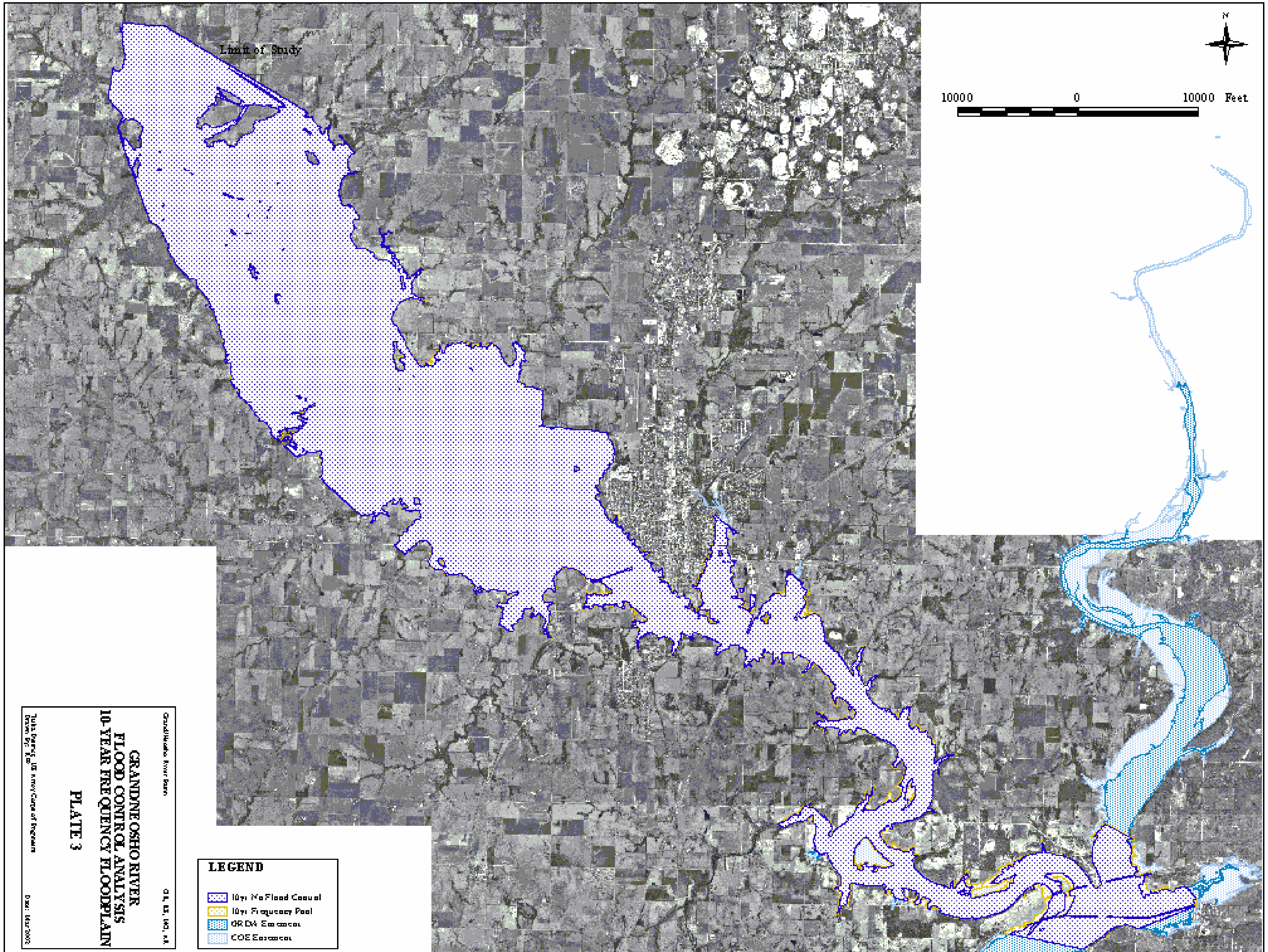
GRAND/NEOSHO RIVER
FLOOD CONTROL ANALYSIS
2-YEAR FREQUENCY FLOODPLAIN
PLATE 1
LEGEND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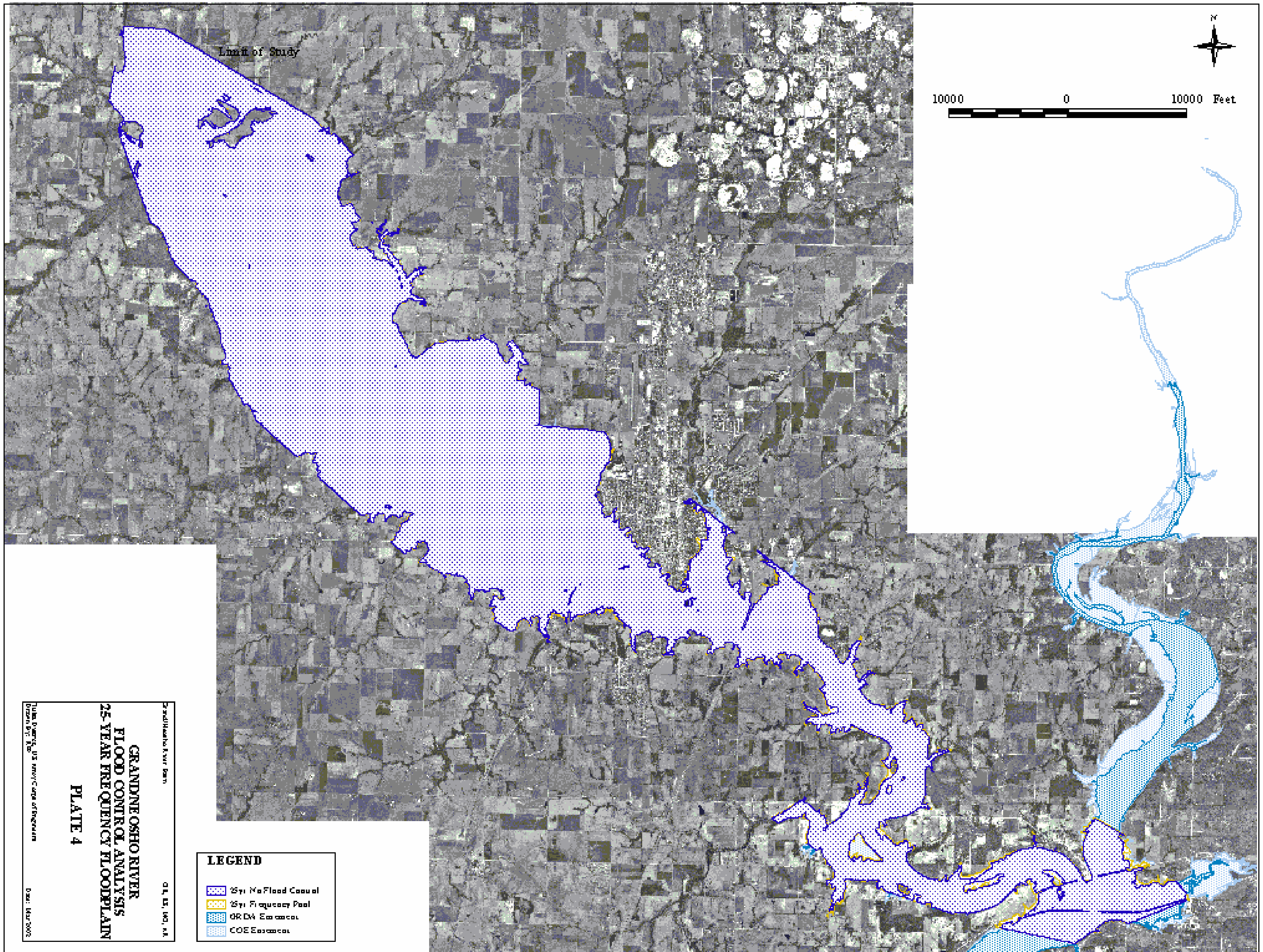
GRAND/NEOSHO RIVER
FLOOD CONTROL ANALYSIS
10-YEAR FREQUENCY FLOODPLAIN
PLATE 3
LEGEND


Limit of Study
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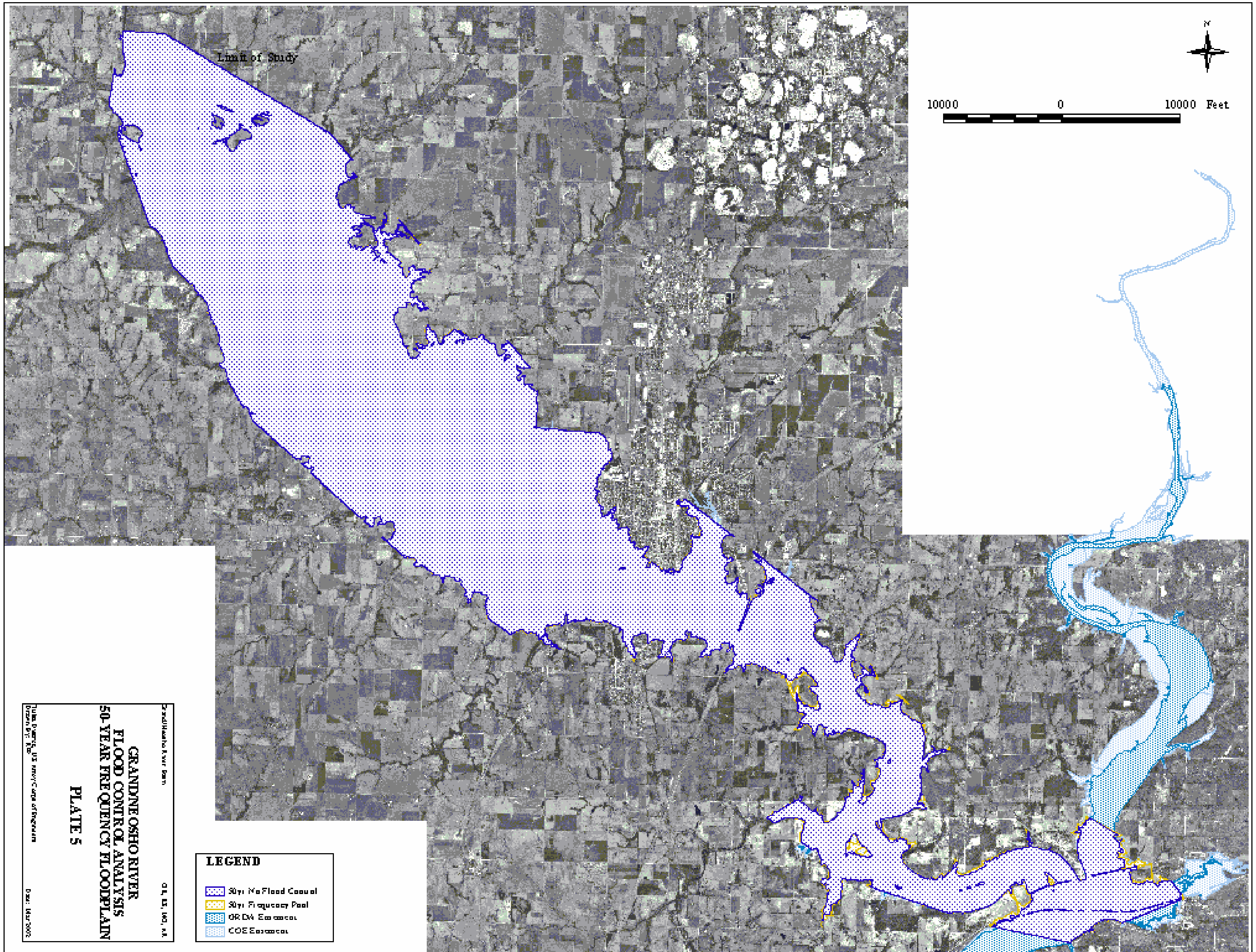
GRAND/NEOSHO RIVER
FLOOD CONTROL ANALYSIS
25-YEAR FREQUENCY FLOODPLAIN
PLATE 4
LEGEND


Limit of Study
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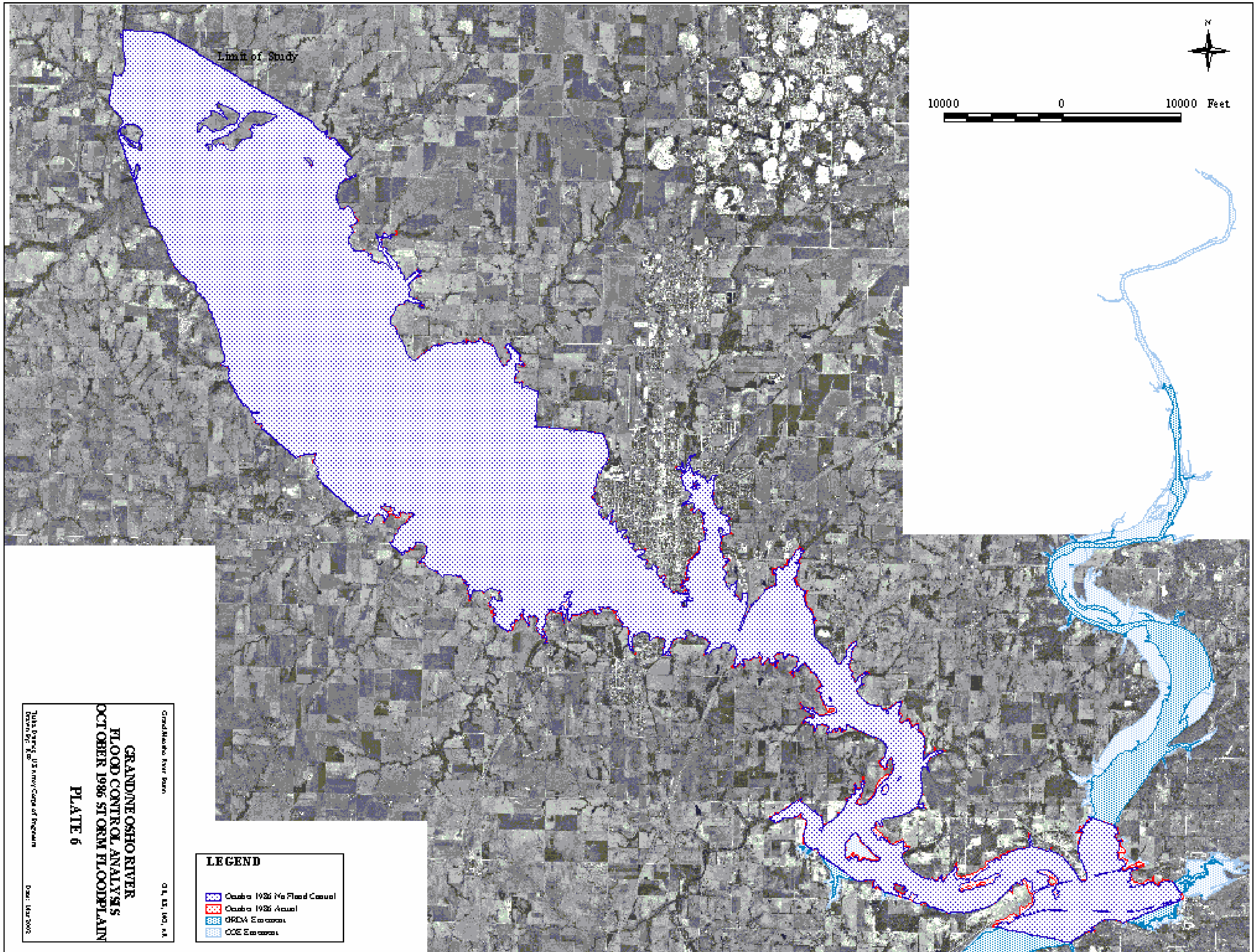
GRAND/NEOSHO RIVER
FLOOD CONTROL ANALYSIS
50-YEAR FREQUENCY FLOODPLAIN
PLATE 5
LEGEND
COE Easement


Limit of Study
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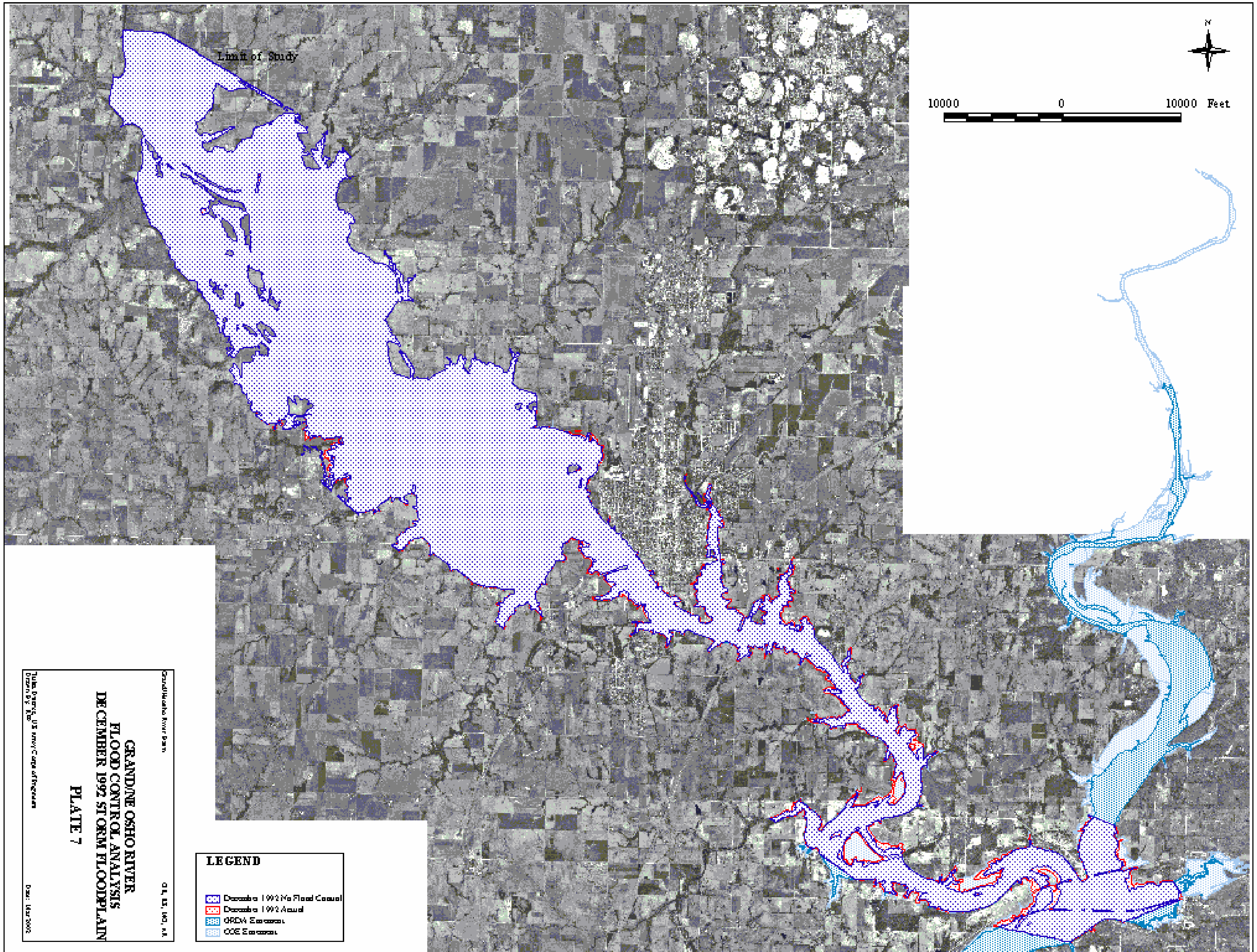
GRAND/NEOSHO RIVER
FLOOD CONTROL ANALYSIS
OCTOBER 1986 STORM FLOODPLAIN
PLATE 6
LEGEND
October 1986 No Flood Control
October 1986 Actual
GRDA Easement
COE Easement


Limit of Study
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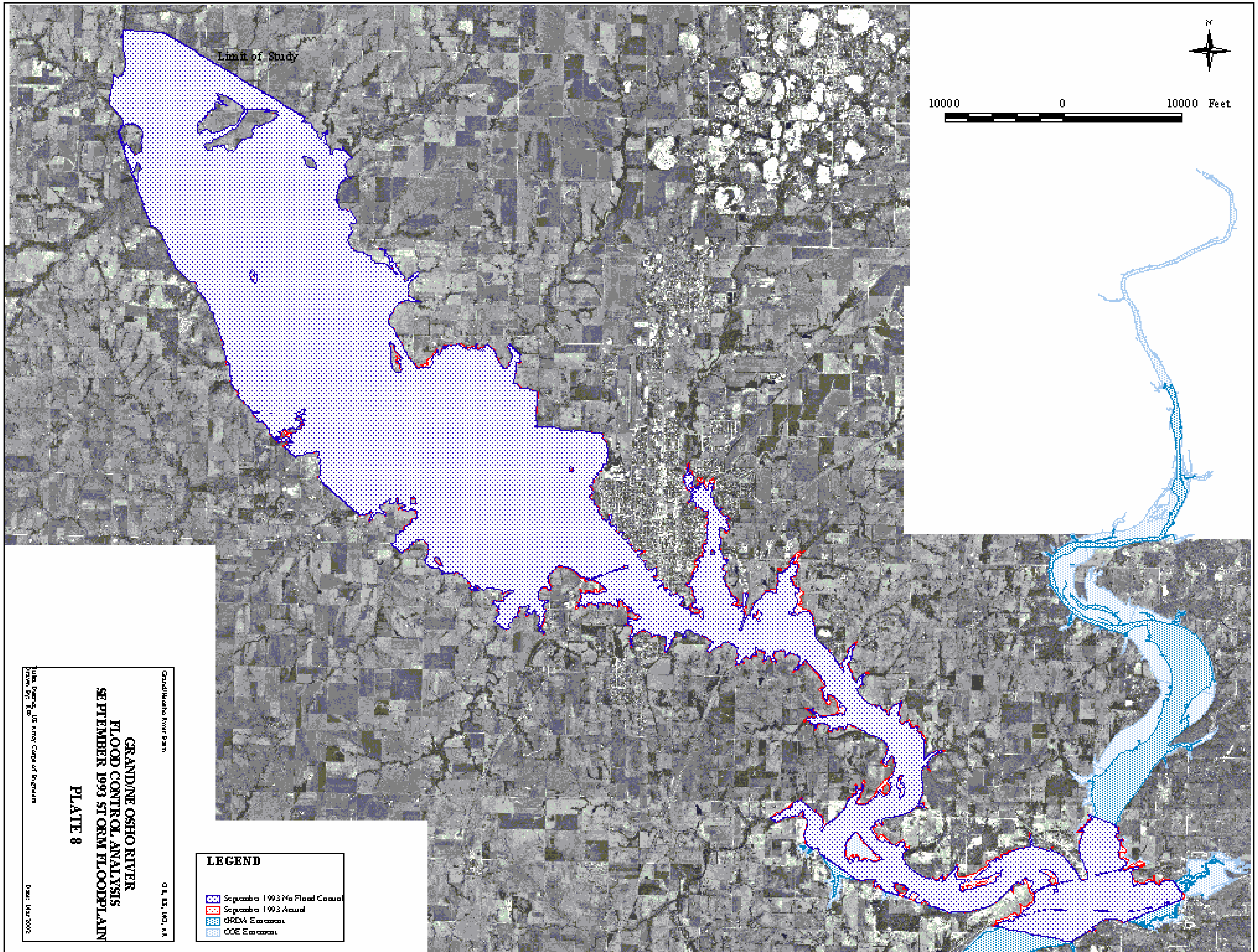
GRAND/NEOSHO RIVER
FLOOD CONTROL ANALYSIS
DECEMBER 1992 STORM FLOODPLAIN
PLATE 7
LEGEND
December 1992 No Flood Control
December 1992 Actual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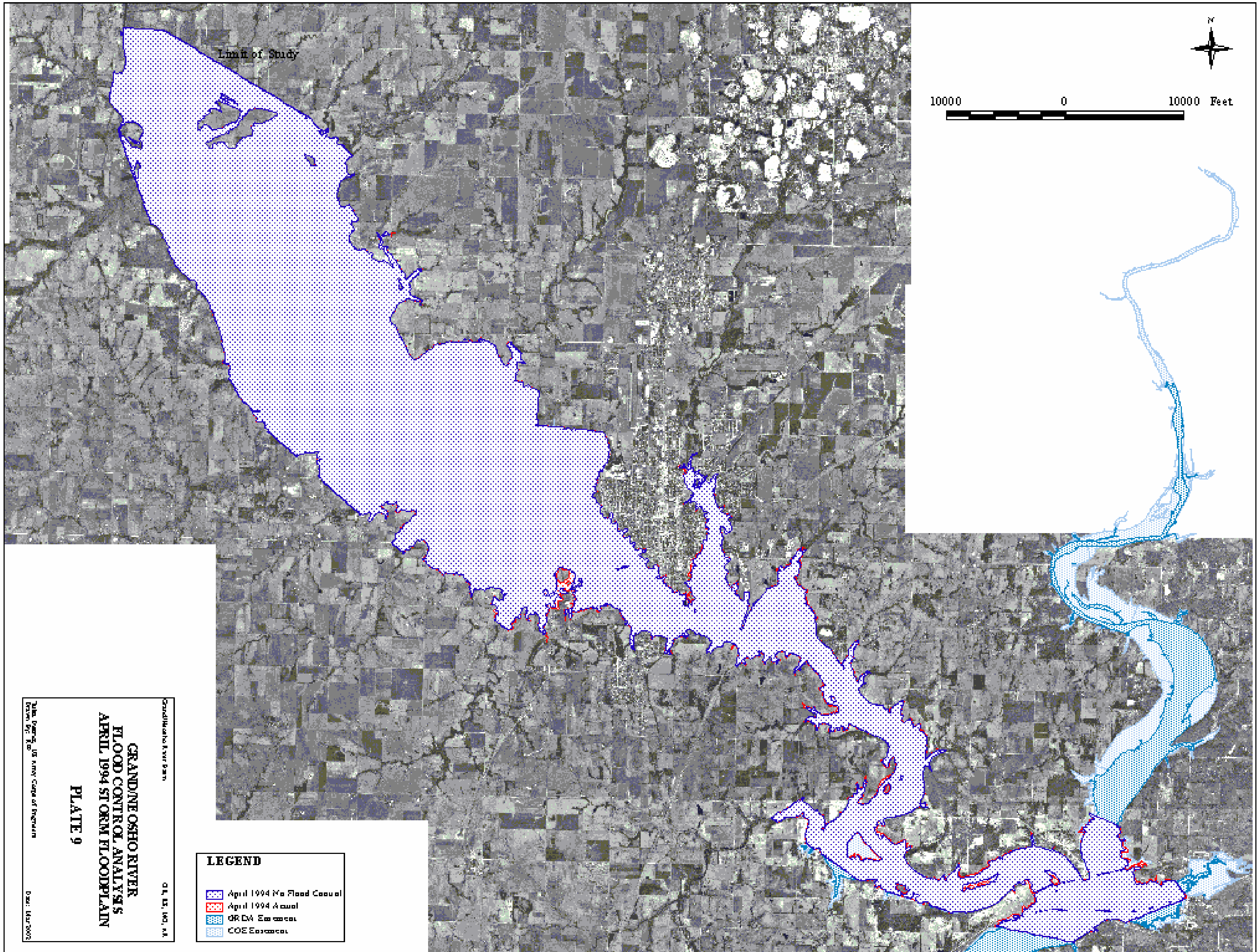
GRAND/NEOSHO RIVER
FLOOD CONTROL ANALYSIS
SEPTEMBER 1993 STORM FLOODPLAIN
PLATE 8
Grand/Neosho River Basin
Tulsa District, US Army Corps of Engineers
LEGEND
September 1993 No Flood Control
September 1993 Actual
GRDA Easement
COE Easement


Limit of Study
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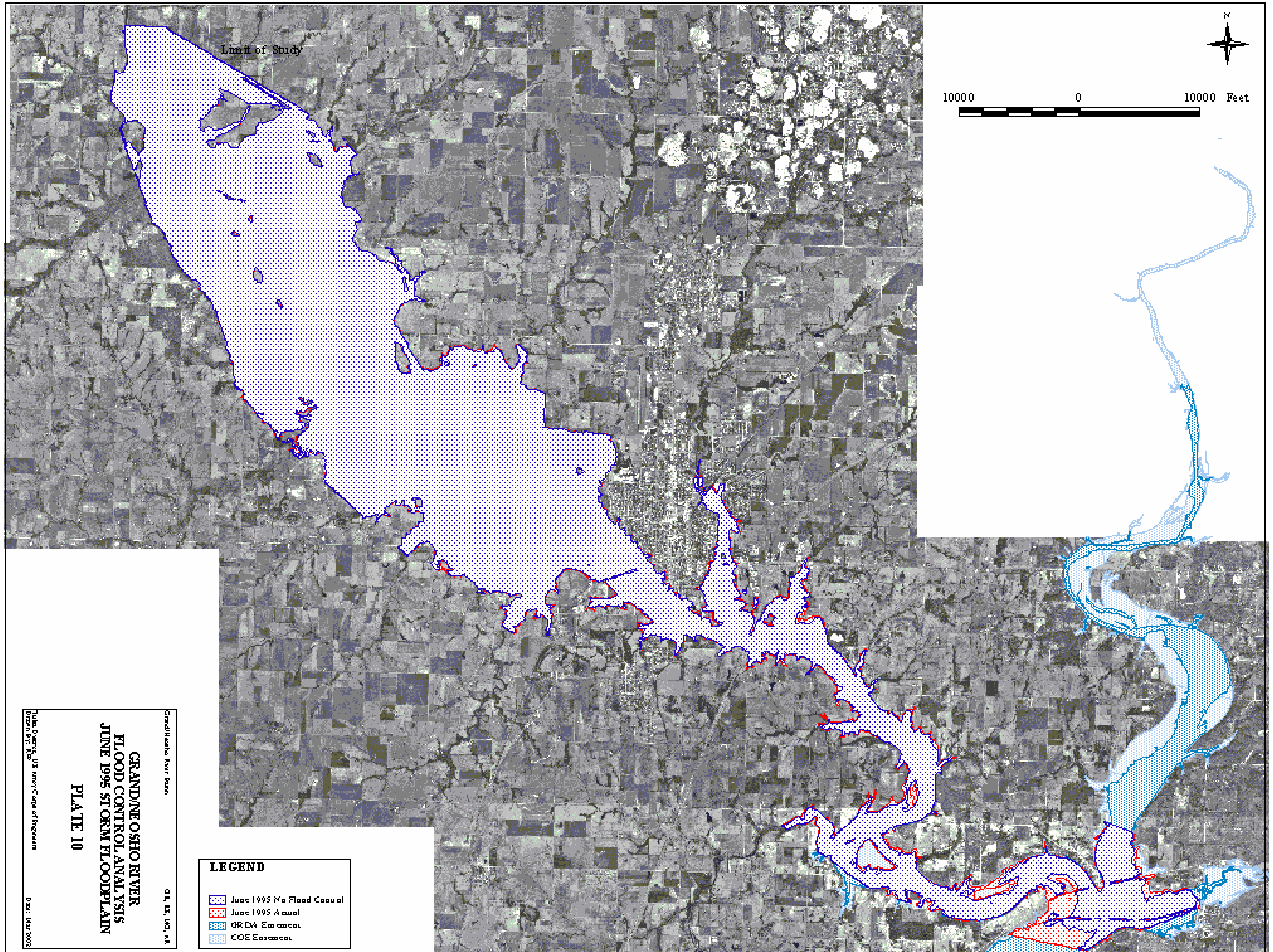
GRAND/NEOSHO RIVER
FLOOD CONTROL ANALYSIS
APRIL 1994 STORM FLOODPLAIN
PLATE 9
LEGEND
April 1994 No Flood Control
April 1994 Actual
COE Easement


Limit of Study
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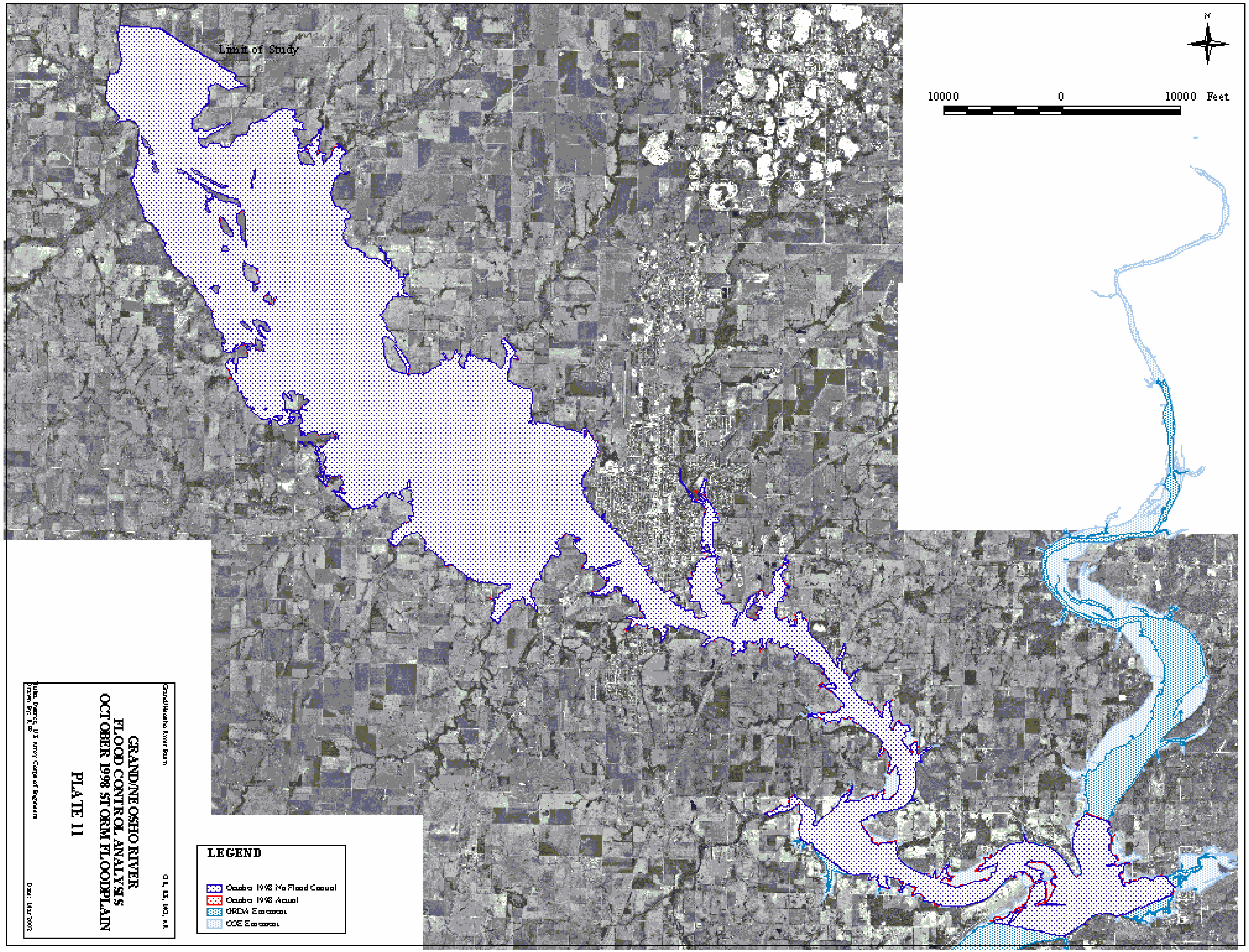
GRAND/NEOSHO RIVER
FLOOD CONTROL ANALYSIS
JUNE 1995 STORM FLOODPLAIN
PLATE 10
Grand/Neosho River Basin
OK, KS, MO, AR
Tulsa District, US Army Corps of Engineers
LEGEND
June 1995 No Flood Control
June 1995 Actual
GRDA Easement
COE Easement


Limit of Study
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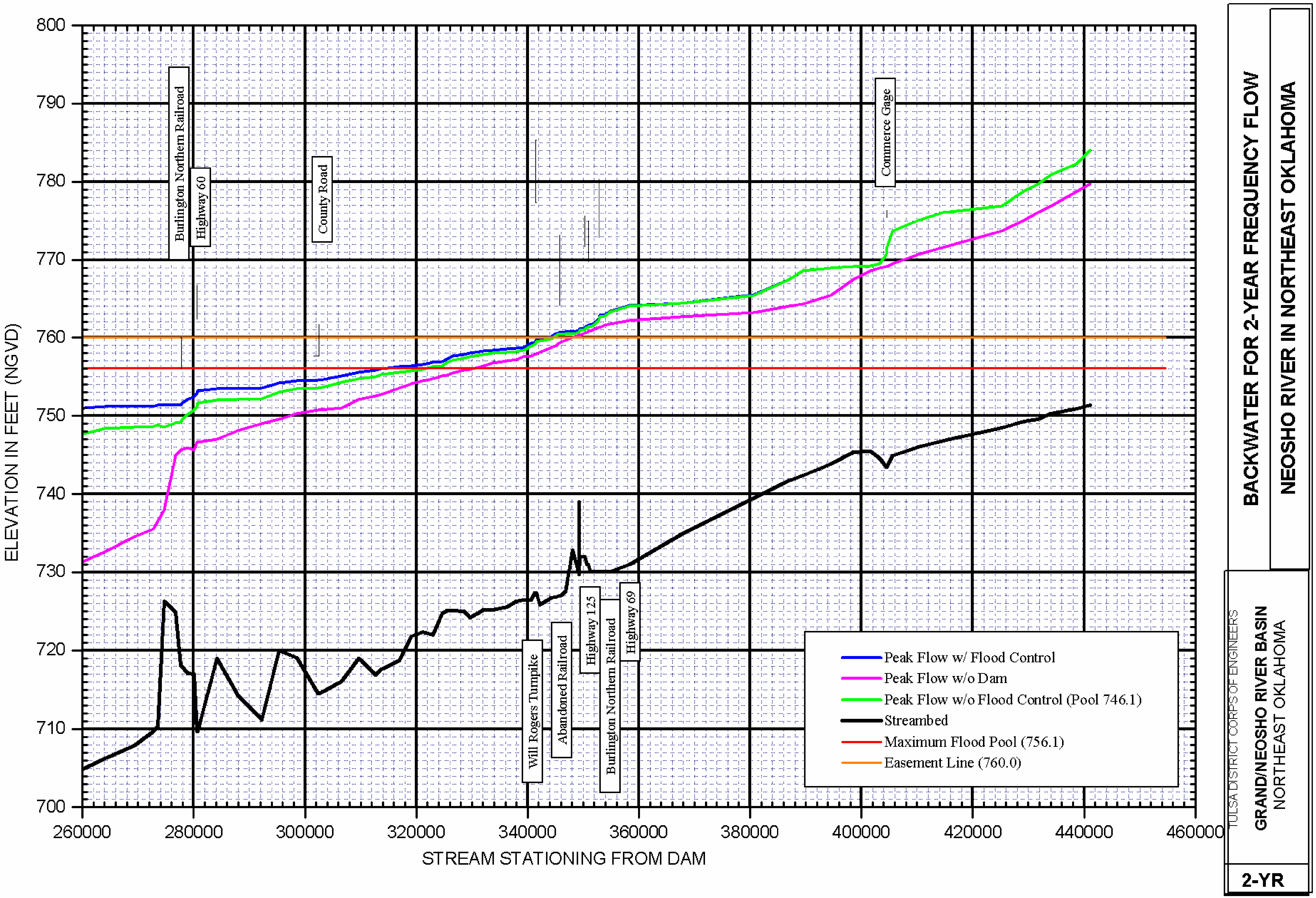
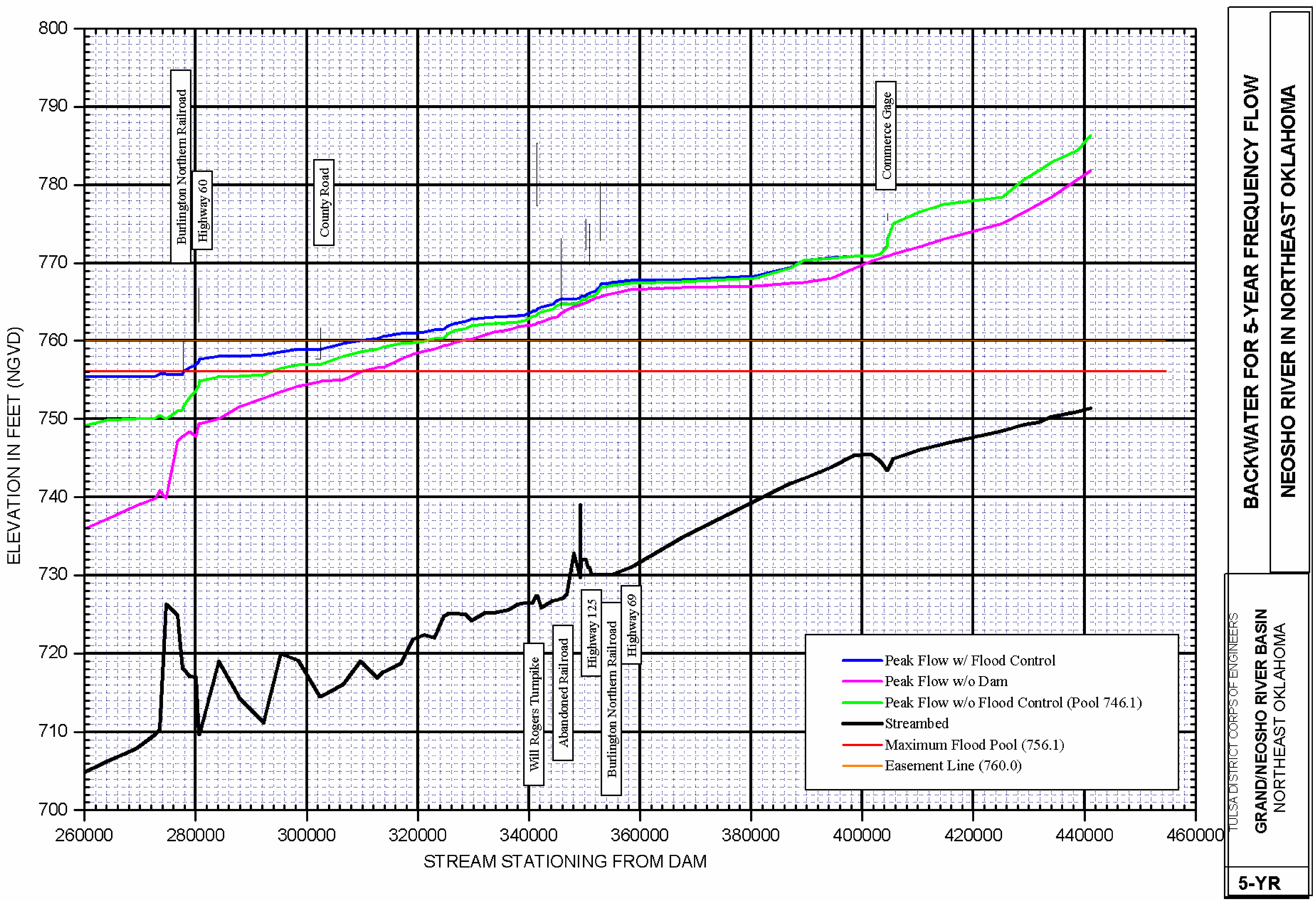
GRAND/NEOSHO RIVER
FLOOD CONTROL ANALYSIS
OCTOBER 1998 STORM FLOODPLAIN
PLATE 11
LEGEND



BACKWATER FOR 2-YEAR FREQUENCY FLOW
NEOSHO RIVER IN NORTHEAST OKLAHOMA
ELEVATION IN FEET (NGVD)
STREAM STATIONING FROM DAM
800
790
780
770
760
750
740
730
720
710
700
260000
280000
300000
320000
340000
360000
380000
400000
420000
440000
460000
Burlington Northern Railroad
Highway 60
County Road
Commerce Gage
Will Rogers Turnpike
Abandoned Railroad
Highway 125
Burlington Northern Railroad
Highway 69
Peak Flow w/ Flood Control
Peak Flow w/o Dam
Peak Flow w/o Flood Control (Pool 746.1)
Streambed
Maximum Flood Pool (756.1)
Easement Line (760.0)
TULSA DISTRICT CORPS OF ENGINEERS
GRAND/NEOSHO RIVER BASIN
NORTHEAST OKLAHOMA
2-YR

Plate 12



BACKWATER FOR 5-YEAR FREQUENCY FLOW
NEOSHO RIVER IN NORTHEAST OKLAHOMA
TULSA DISTRICT CORPS OF ENGINEERS
GRAND/NEOSHO RIVER BASIN
NORTHEAST OKLAHOMA
5-YR
ELEVATION IN FEET (NGVD)
STREAM STATIONING FROM DAM
800
790
780
770
760
750
740
730
720
710
700
260000
280000
300000
320000
340000
360000
380000
400000
420000
440000
460000
Burlington Northern Railroad
Highway 60
County Road
Commerce Gage
Will Rogers Turnpike
Abandoned Railroad
Highway 125
Burlington Northern Railroad
Highway 69
Peak Flow w/ Flood Control
Peak Flow w/o Dam
Peak Flow w/o Flood Control (Pool 746.1)
Streambed
Maximum Flood Pool (756.1)
Easement Line (760.0)

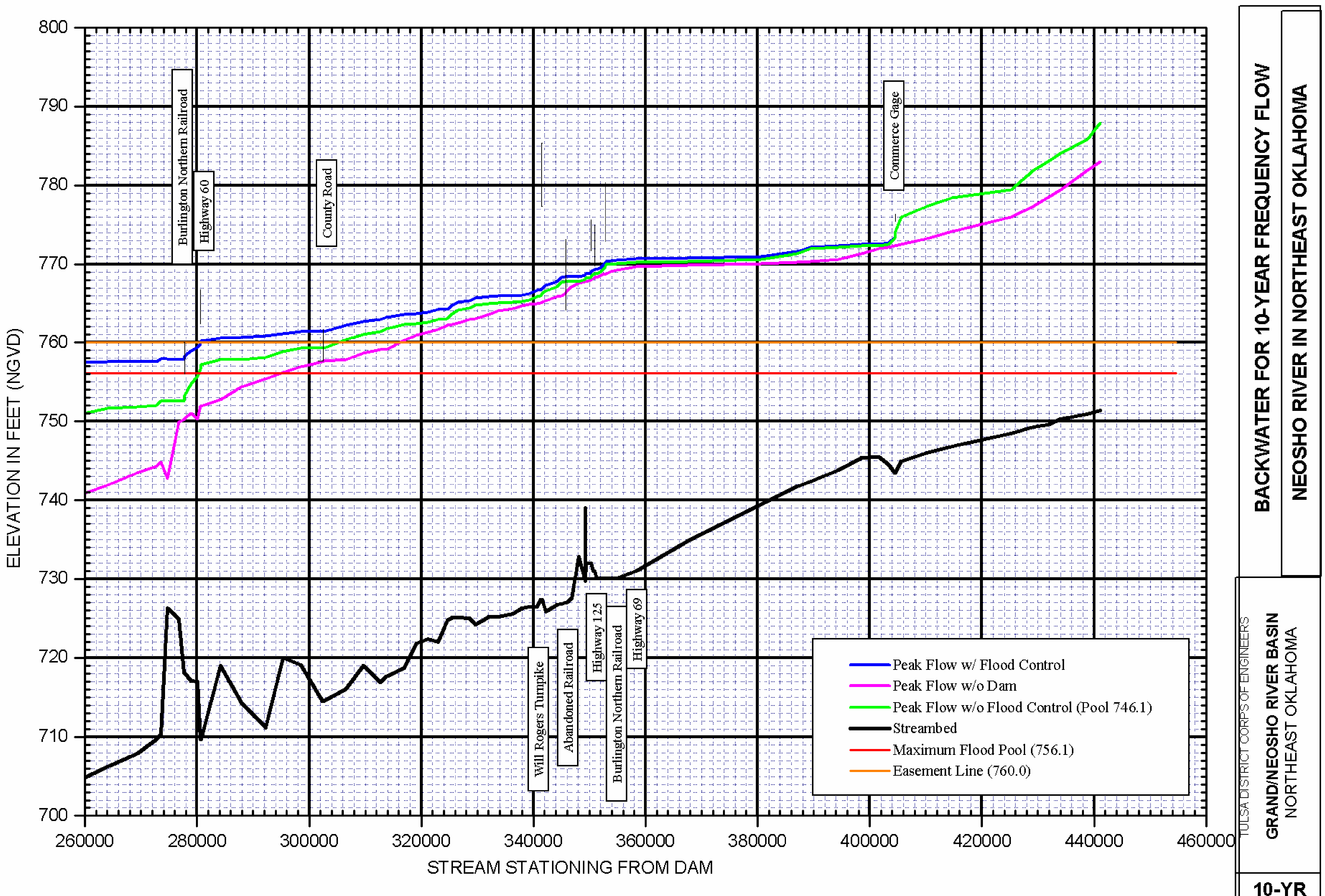
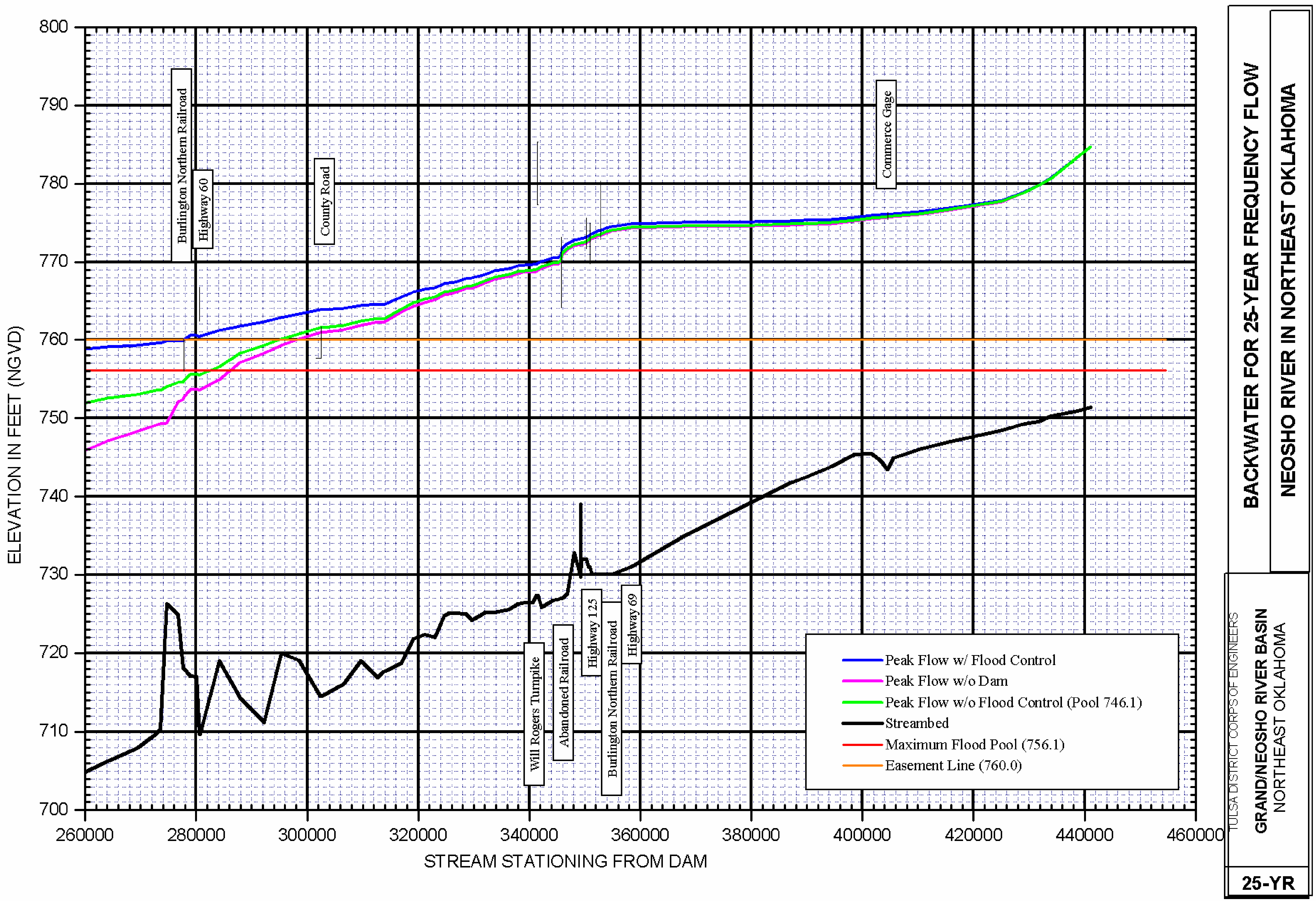
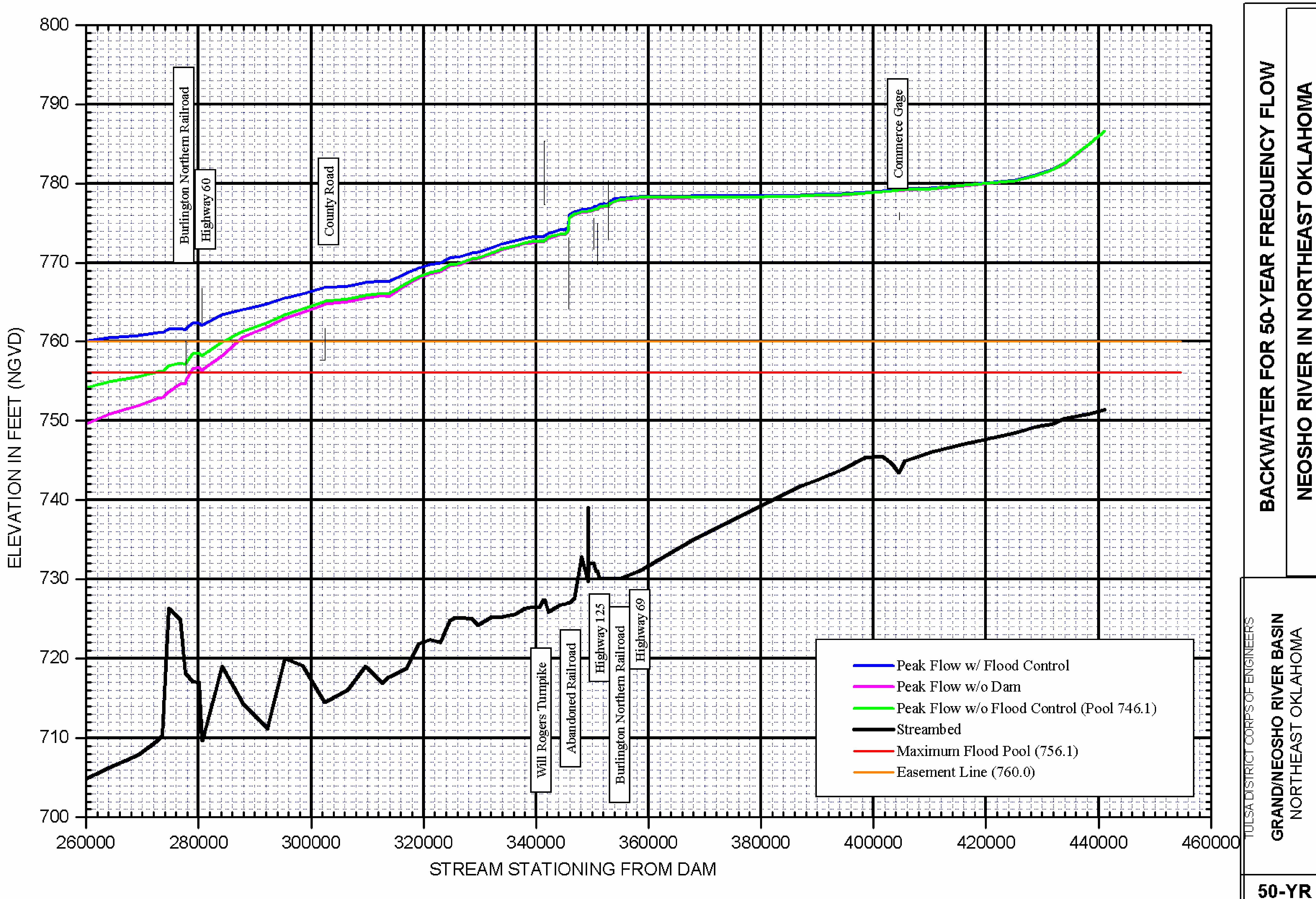

BACKWATER FOR 10-YEAR FREQUENCY FLOW
NEOSHO RIVER IN NORTHEAST OKLAHOMA
ELEVATION IN FEET (NGVD)
STREAM STATIONING FROM DAM
Burlington Northern Railroad
Highway 60
County Road
Commerce Gage
Will Rogers Turnpike
Abandoned Railroad
Highway 125
Burlington Northern Railroad
Highway 69
Peak Flow w/ Flood Control
Peak Flow w/o Dam
Peak Flow w/o Flood Control (Pool 746.1)
Streambed
Maximum Flood Pool (756.1)
Easement Line (760.0)
TULSA DISTRICT CORPS OF ENGINEERS
GRAND/NEOSHO RIVER BASIN
NORTHEAST OKLAHOMA
10-YR

Plate 14



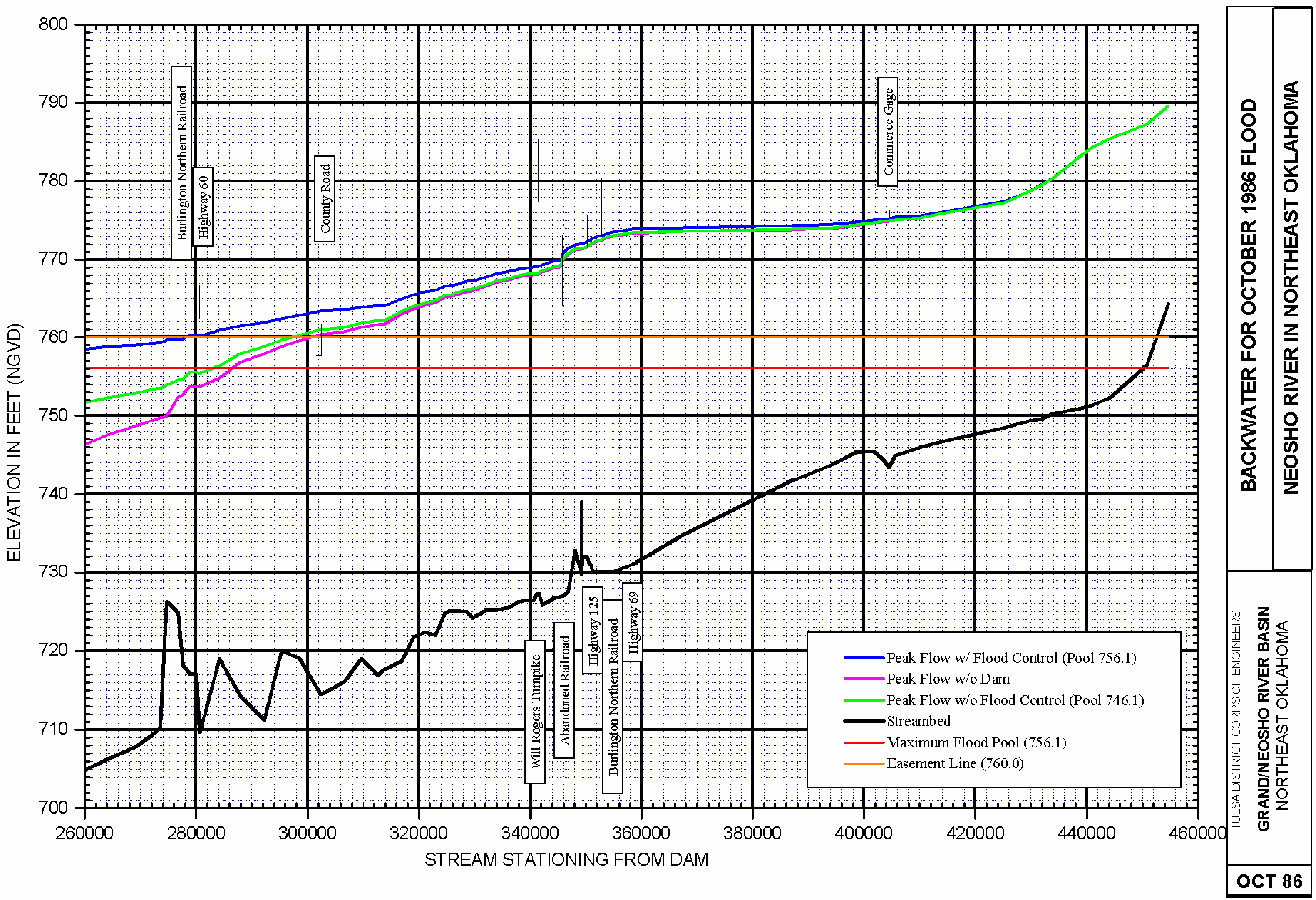
ELEVATION IN FEET (NGVD)
800
790
780
770
760
750
740
730
720
710
700
260000
280000
300000
320000
340000
360000
380000
400000
420000
440000
460000
STREAM STATIONING FROM DAM
Burlington Northern Railroad
Highway 60
County Road
Commerce Gage
Will Rogers Turnpike
Abandoned Railroad
Highway 125
Burlington Northern Railroad
Highway 69
Peak Flow w/ Flood Control
Peak Flow w/o Dam
Peak Flow w/o Flood Control (Pool 746.1)
Streambed
Maximum Flood Pool (756.1)
Easement Line (760.0)
BACKWATER FOR 25-YEAR FREQUENCY FLOW
NEOSHO RIVER IN NORTHEAST OKLAHOMA
TULSA DISTRICT CORPS OF ENGINEERS
GRAND/NEOSHO RIVER BASIN
NORTHEAST OKLAHOMA
25-YR

Plate 15



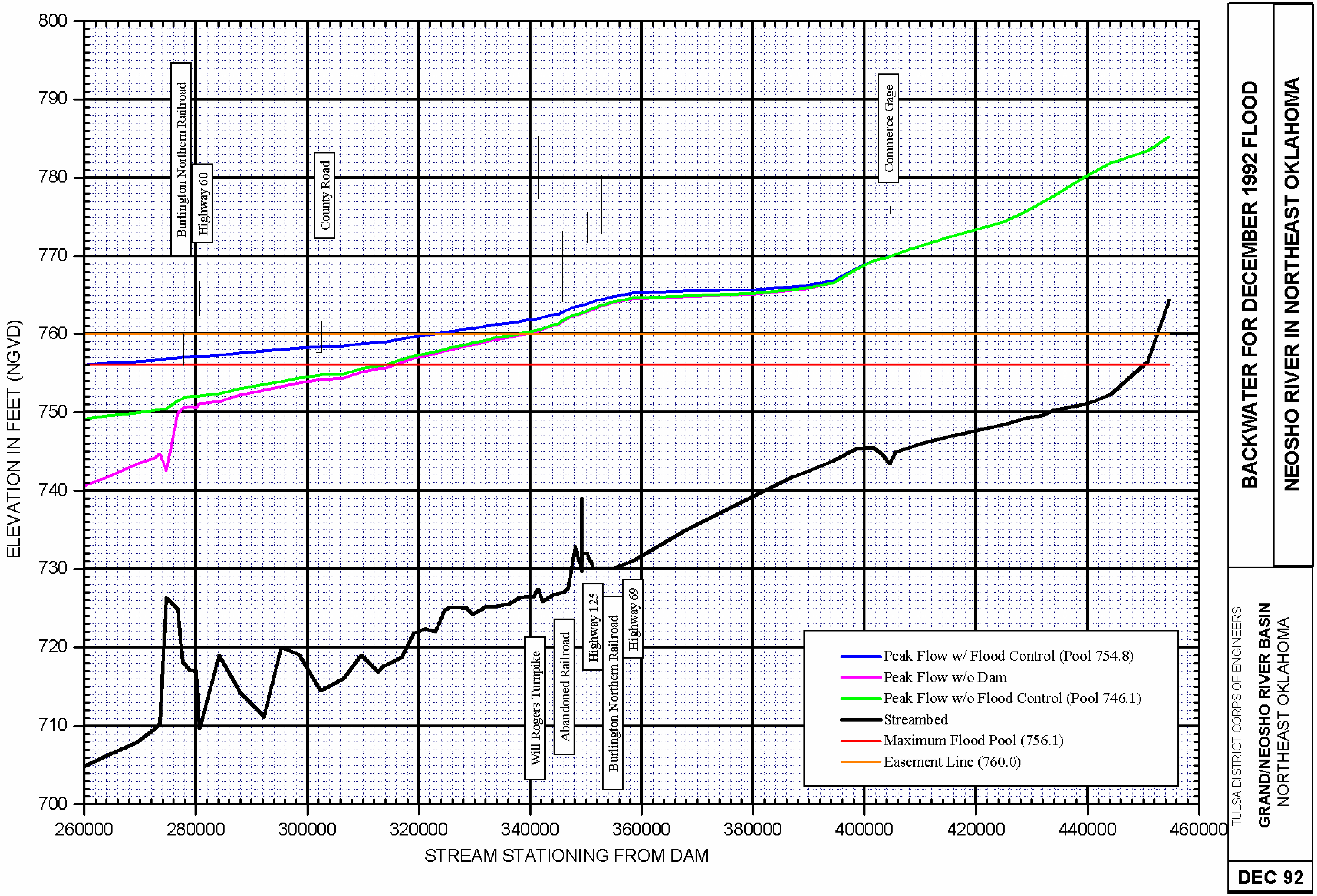
800
790
780
770
760
750
740
730
720
710
700
ELEVATION IN FEET (NGVD)
260000
280000
300000
320000
340000
360000
380000
400000
420000
440000
460000
STREAM STATIONING FROM DAM
Burlington Northern Railroad
Highway 60
County Road
Commerce Gage
Will Rogers Turnpike
Abandoned Railroad
Highway 125
Burlington Northern Railroad
Highway 69
Peak Flow w/ Flood Control
Peak Flow w/o Dam
Peak Flow w/o Flood Control (Pool 746.1)
Streambed
Maximum Flood Pool (756.1)
Easement Line (760.0)
BACKWATER FOR 50-YEAR FREQUENCY FLOW
NEOSHO RIVER IN NORTHEAST OKLAHOMA
TULSA DISTRICT CORPS OF ENGINEERS
GRAND/NEOSHO RIVER BASIN
NORTHEAST OKLAHOMA
50-YR

Plate 16



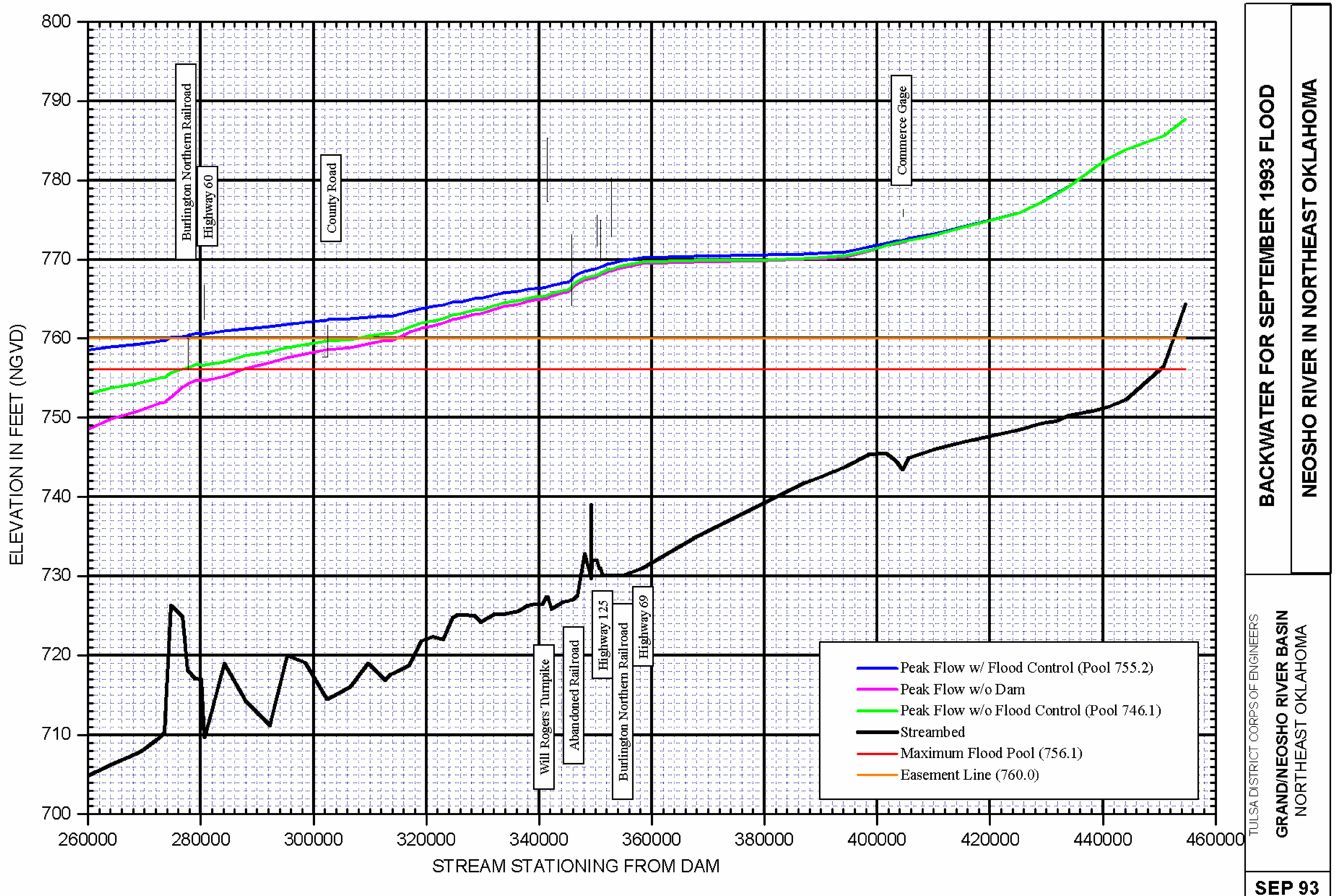
BACKWATER FOR OCTOBER 1986 FLOOD
NEOSHO RIVER IN NORTHEAST OKLAHOMA
TULSA DISTRICT CORPS OF ENGINEERS
GRAND/NEOSHO RIVER BASIN
NORTHEAST OKLAHOMA
OCT 86
ELEVATION IN FEET (NGVD)
STREAM STATIONING FROM DAM
800
790
780
770
760
750
740
730
720
710
700
260000
280000
300000
320000
340000
360000
380000
400000
420000
440000
460000
Burlington Northern Railroad
Highway 60
County Road
Commerce Gage
Will Rogers Turnpike
Abandoned Railroad
Highway 125
Burlington Northern Railroad
Highway 69
Peak Flow w/ Flood Control (Pool 756.1)
Peak Flow w/o Dam
Peak Flow w/o Flood Control (Pool 746.1)
Streambed
Maximum Flood Pool (756.1)
Easement Line (760.0)

Plate 17



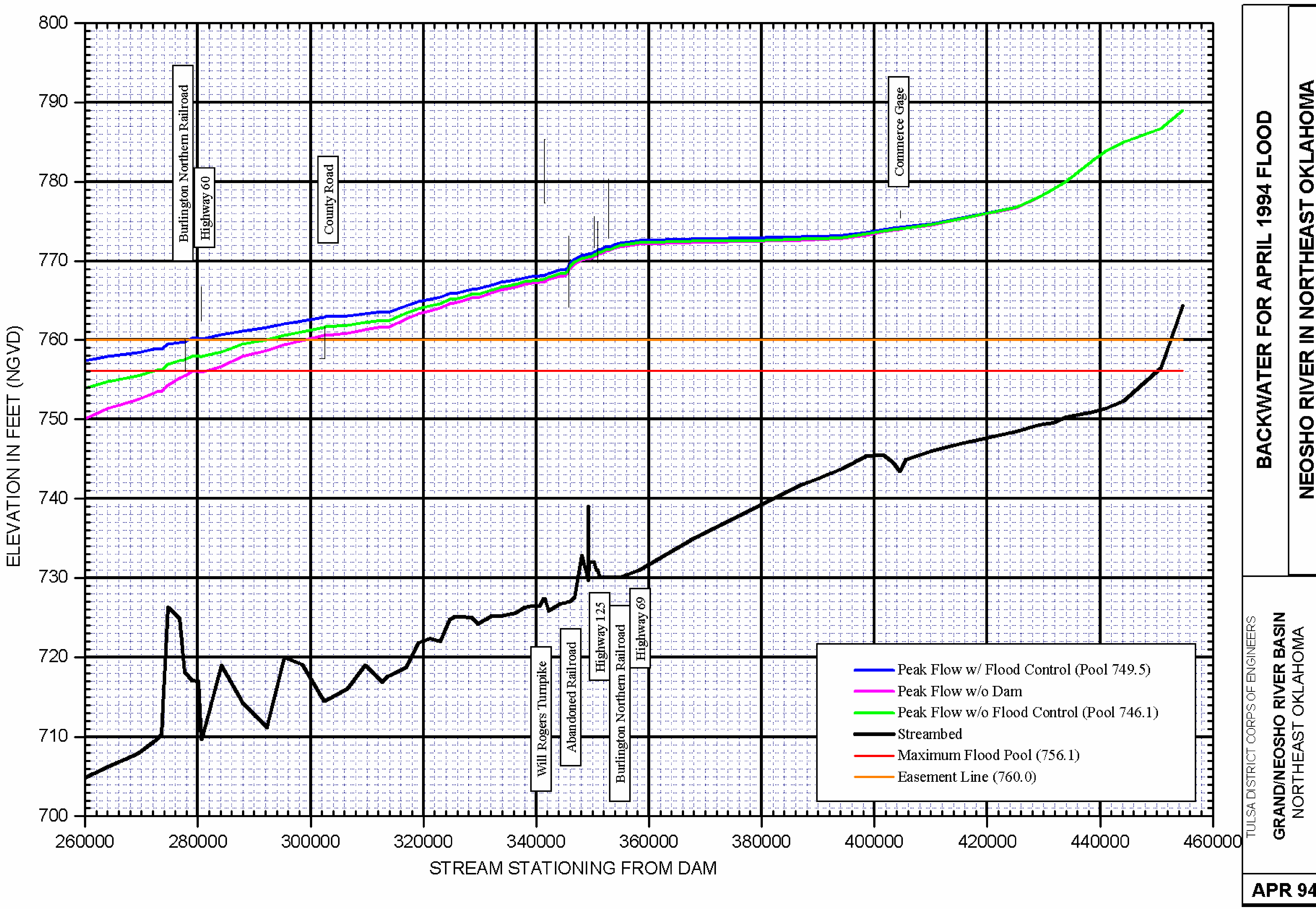
ELEVATION IN FEET (NGVD)
800
790
780
770
760
750
740
730
720
710
700
260000
280000
300000
320000
340000
360000
380000
400000
420000
440000
460000
STREAM STATIONING FROM DAM
Burlington Northern Railroad
Highway 60
County Road
Commerce Gage
Will Rogers Turnpike
Abandoned Railroad
Highway 125
Burlington Northern Railroad
Highway 69
Peak Flow w/ Flood Control (Pool 754.8)
Peak Flow w/o Dam
Peak Flow w/o Flood Control (Pool 746.1)
Streambed
Maximum Flood Pool (756.1)
Easement Line (760.0)
BACKWATER FOR DECEMBER 1992 FLOOD
NEOSHO RIVER IN NORTHEAST OKLAHOMA
TULSA DISTRICT CORPS OF ENGINEERS
GRAND/NEOSHO RIVER BASIN
NORTHEAST OKLAHOMA
DEC 92

Plate 18

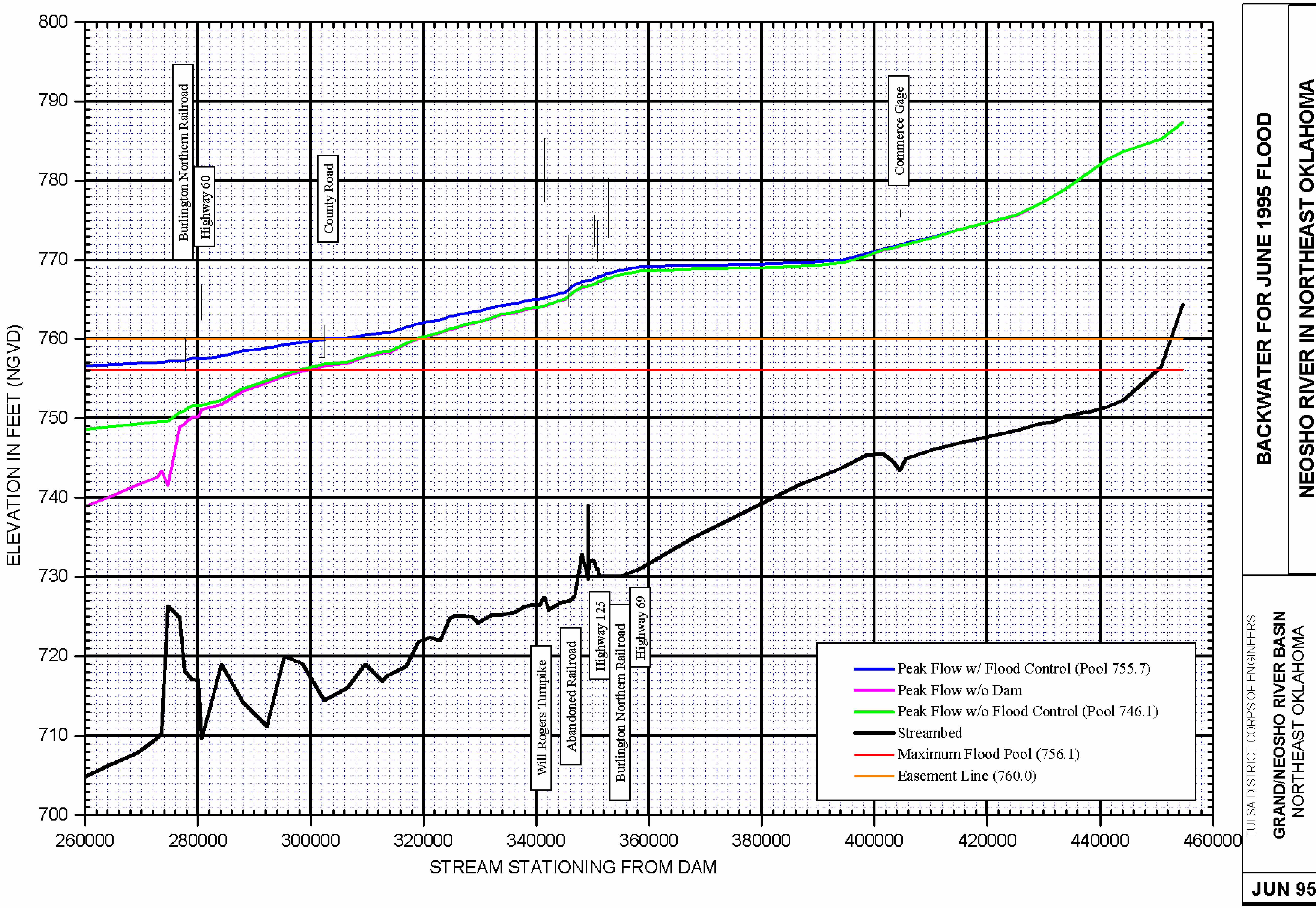


800
790
780
770
760
750
740
730
720
710
700
ELEVATION IN FEET (NGVD)
260000
280000
300000
320000
340000
360000
380000
400000
420000
440000
460000
STREAM STATIONING FROM DAM
Burlington Northern Railroad
Highway 60
County Road
Commerce Gage
Will Rogers Turnpike
Abandoned Railroad
Highway 125
Burlington Northern Railroad
Highway 69
Peak Flow w/ Flood Control (Pool 755.2)
Peak Flow w/o Dam
Peak Flow w/o Flood Control (Pool 746.1)
Streambed
Maximum Flood Pool (756.1)
Easement Line (760.0)
BACKWATER FOR SEPTEMBER 1993 FLOOD
NEOSHO RIVER IN NORTHEAST OKLAHOMA
TULSA DISTRICT CORPS OF ENGINEERS
GRAND/NEOSHO RIVER BASIN
NORTHEAST OKLAHOMA
SEP 93

Plate 19



BACKWATER FOR APRIL 1994 FLOOD
NEOSHO RIVER IN NORTHEAST OKLAHOMA
TULSA DISTRICT CORPS OF ENGINEERS
GRAND/NEOSHO RIVER BASIN
NORTHEAST OKLAHOMA
APR 94
ELEVATION IN FEET (NGVD)
STREAM STATIONING FROM DAM
800
790
780
770
760
750
740
730
720
710
700
260000
280000
300000
320000
340000
360000
380000
400000
420000
440000
460000
Burlington Northern Railroad
Highway 60
County Road
Commerce Gage
Will Rogers Turnpike
Abandoned Railroad
Highway 125
Burlington Northern Railroad
Highway 69
Peak Flow w/ Flood Control (Pool 749.5)
Peak Flow w/o Dam
Peak Flow w/o Flood Control (Pool 746.1)
Streambed
Maximum Flood Pool (756.1)
Easement Line (760.0)



BACKWATER FOR JUNE 1995 FLOOD
NEOSHO RIVER IN NORTHEAST OKLAHOMA
TULSA DISTRICT CORPS OF ENGINEERS
GRAND/NEOSHO RIVER BASIN
NORTHEAST OKLAHOMA
JUN 95
ELEVATION IN FEET (NGVD)
STREAM STATIONING FROM DAM
800
790
780
770
760
750
740
730
720
710
700
260000
280000
300000
320000
340000
360000
380000
400000
420000
440000
460000
Burlington Northern Railroad
Highway 60
County Road
Commerce Gage
Will Rogers Turnpike
Abandoned Railroad
Highway 125
Burlington Northern Railroad
Highway 69
Peak Flow w/ Flood Control (Pool 755.7)
Peak Flow w/o Dam
Peak Flow w/o Flood Control (Pool 746.1)
Streambed
Maximum Flood Pool (756.1)
Easement Line (760.0)

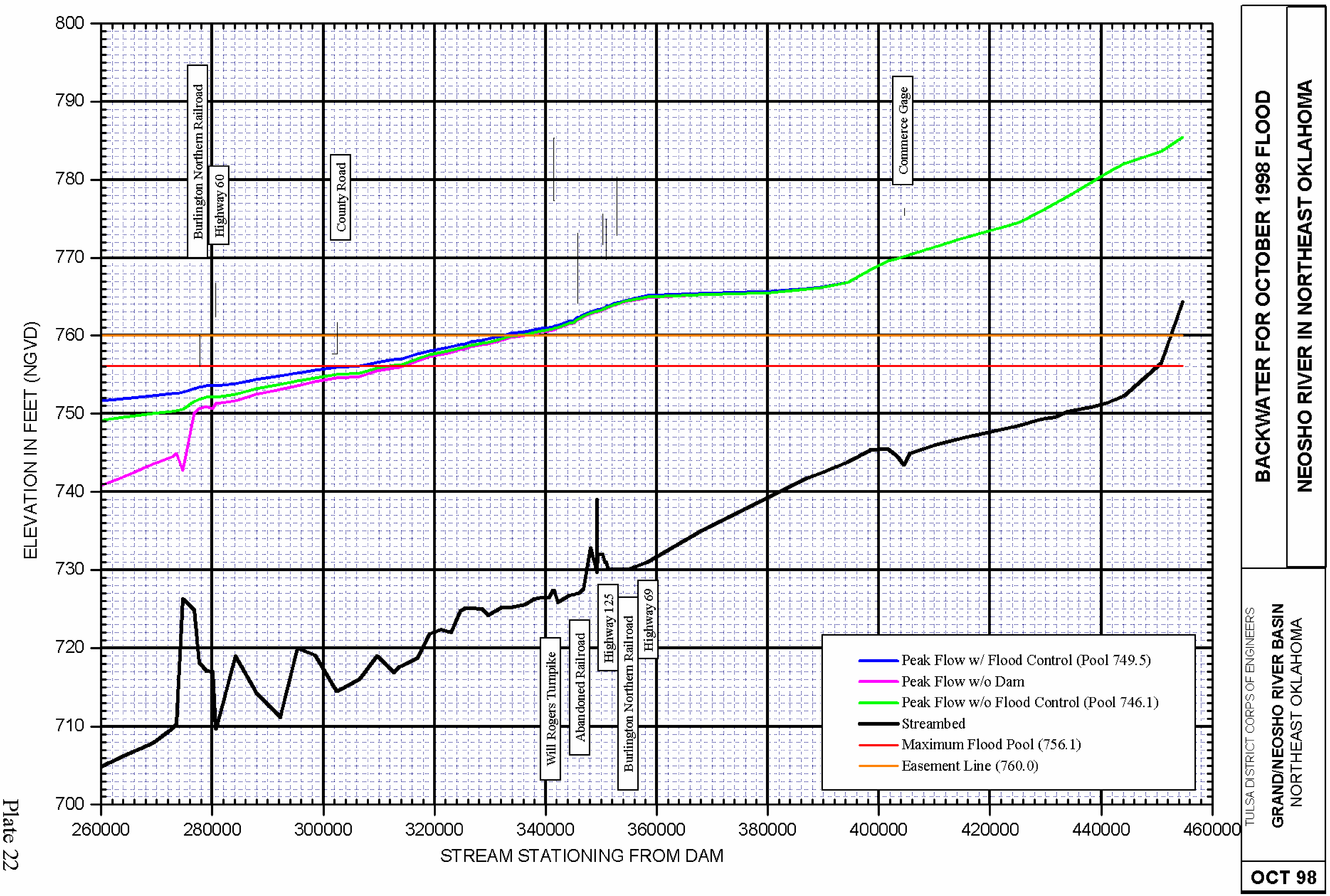

BACKWATER FOR OCTOBER 1998 FLOOD
NEOSHO RIVER IN NORTHEAST OKLAHOMA
TULSA DISTRICT CORPS OF ENGINEERS
GRAND/NEOSHO RIVER BASIN
NORTHEAST OKLAHOMA
OCT 98
ELEVATION IN FEET (NGVD)
STREAM STATIONING FROM DAM
Burlington Northern Railroad
Highway 60
County Road
Commerce Gage
Will Rogers Turnpike
Abandoned Railroad
Highway 125
Burlington Northern Railroad
Highway 69
Peak Flow w/ Flood Control (Pool 749.5)
Peak Flow w/o Dam
Peak Flow w/o Flood Control (Pool 746.1)
Streambed
Maximum Flood Pool (756.1)
Easement Line (760.0)
700
710
720
730
740
750
760
770
780
790
800
260000
280000
300000
320000
340000
360000
380000
400000
420000
440000
460000

Plate 22